BIOGRAPHICAL SKETCH

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NAME: **Ugurbil, Kamil**

eRA COMMONS USER NAME (credential, e.g., agency login): ugurbil

POSITION TITLE: **Professor / Director**

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Columbia University, New York, NY	B.A.	1971	Physics
Columbia University, New York, NY	M.A.	1974	Chemical Physics
Columbia University, New York, NY	Ph.D.	1977	Chemical Physics

A. Personal Statement

My research centers around magnetic resonance (MR) imaging and spectroscopy in general, ultrahigh field (UHF) MR methodology and instrumentation in particular, and the use of these methods in biomedical applications, predominantly in the study of brain function. In this area, the team I lead at the Center for Magnetic Resonance Research (CMRR), the University of Minnesota, is internationally recognized for their pioneering contributions, including the introduction of the functional imaging method for imaging brain activity (fMRI), studies aimed at elucidating fMRI mechanisms, the introduction of ultra high magnetic field (UHF) MR for imaging studies of brain function and neurochemistry in human and animal models, unique applications of UHF techniques in human and animal model studies to achieve for the first time functional maps at the level of neuronal ensembles that represent elementary computational units (e.g. cortical columns and layers), and the development of numerous novel technologies and imaging methods, particularly for very high magnetic field fMRI and structural imaging. A recent example of this activity is the NIH funded Human Connectome Project (HCP) where I led the technology development effort that has introduced the highly accelerated imaging and image reconstruction approaches that have dramatically altered the way human brain functional and diffusion weighted (dMRI) imaging is currently performed.

In addition, as the director of a large and scientifically successful MR center, the CMRR, I establish, oversee, support, and lead multi-project, multi-investigator, and even multi-institutional grants as the PI (e.g. an NCRR/NIBIB Biotechnology Research Center (BTRC) P41 grant which will started its 25th year of funding in May 2017, an NINDS P30 grant, the afore mentioned Human Connectome Project (joint PI with David Van Essen from Washington University, St. Louis), HCP-Lifespan project, and a BRAIN Initiative U01 grant involving four institutions.

B. Positions and Honors

Positions:

1977 – 1979: Bell Laboratories: Postdoctoral Fellow
1979 – 1982: Assistant Professor, Columbia University: (Biochemistry)
1982 – 1985: Associate Professor, University of Minnesota (Biochemistry)
1985 – present: Professor, Univ. of Minnesota: (Radiology, Biochemistry, Medicine, and Neurosciences)
1991 – present: Founding Director, Center for Magnetic Resonance Research (CMRR), Univ. of Minnesota
1995 – 2003: Margaret & H.O. Peterson Chair of Neuroradiology, CMRR, Dept. of Radiology
2003 – 2008: Founding Director, Max-Planck Institut, Hochfeld Magnetresonanz Zentrum, Tübingen
2003 – present: McKnight Presidential Endowed Chair Professor, University of Minnesota

Other Experiences and Professional Memberships

2017 - Scientific Advisory Board of Neurospin, INSERM-CEA-University Paris Saclay
2014 - Advisory Editor, *Neural Computation* Journal
2013 - 2014 "BRAIN" Initiative Working Group

2012 - 2017 National Institute of Mental Health (NIMH), Board of Scientific Advisors
2006 - 2016 European Research Council (ERC), Life Science Panel
2000 - 2013 Advisory Board, Stanford University MR Center, Palo Alto, California
2001 - 2006 Editorial Board, Journal of Neurophysiology;
1987 - 2003 Editorial Board, NMR in Biomedicine; Journal
1997 - 2003 Advisory Board; Medical College of Wisconsin, MR Center
1997 - 2002 Program Review Board (Fachbeirat), Max Planck Institute, Leipzig, Germany
1997 - 2000 Scientific Program Committee International Society of Magnetic Resonance Imaging
1996 - 1999 Associate Editor, Journal of Magnetic Resonance (JMR)
1989 - 1994 Journal Editorial Board, Biochemical Journal
1988 - 1994 Advisory Board, National Magnet Lab, Massachusetts Institute of Technology
1988 - 1991 Trustee of the International Society of Magnetic Resonance in Medicine
1987 - 1989 Advisory Board, Center for Nuclear Imaging Research (CNIR), University of Alabama
1986 - present Member, International Society of Magnetic Resonance in Medicine (ISMRM)

Honors:

2016 Vehbi Koç Award
2015 Distinguished Fellow, SAGE Center for the Study of the Mind
2014 Richard Ernst Medal and Lecture (ETH, Zürich)
2014 Elected into National Academy of Inventors
2013 Erwin Hahn Lecture, Erwin Hahn Institute, Essen, Germany
2013 Elected to Academy of Device Innovators, University of Minnesota
2011 Honorary Doctorate (Doctorate Honoris Causa), University of Maastricht, Netherlands
2010 Centennial Lecture, University of Florida, Gainesville
2010 5th Annual Glen D. Dobben Memorial Lecture, University of Illinois, Chicago
2009 Sir Peter Mansfield Lecture, European Society of Magnetic Resonance in Medicine and Biology
2009 Elected Fellow of the International Society of Magnetic Resonance (ISMAR) Fellow.
2007 Elected into the National academy of Medicine (USA)
2005 Elected into the American Academy of Arts and Sciences
2005 Honorary Doctorate (Doctorate Honoris Causa), University of Utrecht, Netherlands
2003 McKnight Presidential Endowed Chair Professorship, University of Minnesota
2001 Science Day Lecturer, Swiss Federal Institute of Technology (EPFL), Lausanne
1996 Margaret & H.O. Peterson Chair Professorship, University of Minnesota
1997 Inducted as Fellow, International Society of Magnetic Resonance in Medicine (ISMRM)
1996 Gold Medal, the International Society of Magnetic Resonance in Medicine (ISMRM)
1983 NIH Research Career Development Award
1980 Irma T. Hirschl Career Scientist Award
1976 Recipient of Hammett Award for Original and Distinguished Research
1974 Columbia University, Graduate Faculties Alumni Scholar

C. Contribution to Science

1. **Discovery of Functional Magnetic Resonance (fMRI)**. The introduction of fMRI was accomplished in two laboratories independently and simultaneously in 1991-1992, one of which was mine at the University of Minnesota. Using manipulations of the physiologic state of the anesthetized animal, such as altering oxygen content of inhaled gas, S. Ogawa from Bell Laboratories described in 1990 the effect of deoxyhemoglobin on MR images of the brain, and named it Blood Oxygenation Dependent (BOLD) contrast. In collaboration with Ogawa, I undertook experiments in my laboratory that aimed at using BOLD contrast to map human brain activity, leading to the successful demonstration of functional mapping in the human brain. This landmark effort was also accompanied by the first modeling and experimental papers aimed at elucidating the mechanism underlying the functional imaging signals.
    a. Ogawa S, Tank DW, Menon R, Ellermann JM, Kim SG, Merkle H, **Ugurbil K**. (1992). “Intrinsic signal changes accompanying sensory stimulation: functional brain mapping with magnetic resonance imaging.” Proc Natl Acad Sci U S A 89(13): 5951-5955. PMCID: PMC402116.
    b. Ogawa S, Menon RS, Tank DW, Kim SG, Merkle H, Ellermann JM, **Ugurbil K**. (1993). “Functional brain mapping by blood oxygenation level-dependent contrast magnetic resonance imaging. A comparison of signal characteristics with a biophysical model.” Biophys J 64(3): 803-812. PMCID: PMC1262394.

2. **Understanding the underlying mechanisms and the charecteristics of Functional mapping signlas in fMRI towards developing functional imaging at the level of cortical layers and columns**. The ability to obtain functional maps at the level of minimal architectural units that organize neural populations of similar properties is critical for understanding brain function. The cortical columns of neocortex are prominent examples of such structurally and functionally specialized units and have received extensive attention in studies of brain function using electrophysiology, optical imaging, and computational modeling. In addition, because of differences in connectivity and cell types across the few millimeter thick cortex, laminar resolution is also critical in deciphering brain function. However, ability to image at such spatial scales cannot *a priori* assumed with fMRI because fMRI signals reflect neuronal activity indirectly through neurovascular coupling and vasculature. My group made seminal and pioneering contributions towards understanding the mechanisms underlying fMRI signals, the spatial scale of neurovascular coupling, and the nature of mapping signal with different functional contrast encoding approaches; we then exploited this knowledge to develop methods (including ultrahigh field MR (see below)) to functional mapping at the level of cortical columns and layers in the human brain for the first time.
    a. Duong TQ, Kim DS, **Ugurbil K**, Kim SG. (2001). "Localized cerebral blood flow response at submillimeter columnar resolution." Proc Natl Acad Sci U S A 98, 10904-10909. PMCID: PMC58572.
    b. Shmuel A, Yacoub E, Pfeuffer J, Van de Moortele PF, Adriany G, Hu X, **Ugurbil K**. (2002). "Sustained negative BOLD, blood flow and oxygen consumption response and its coupling to the positive response in the human brain." Neuron 36, 1195-1210.
    c. Shmuel A, Yacoub E, Chaimow D, Logothetis NK, **Ugurbil K**. (2007). "Spatio-temporal point-spread function of fMRI signal in human gray matter at 7 Tesla." Neuroimage 35, 539-552. PMCID: PMC2989431.
    d. Yacoub E, Harel N, **Ugurbil K**. (2008). "High-field fMRI unveils orientation columns in humans." Proc Natl Acad Sci U S A 105, 10607-10612. PMCID: PMC2492463.
3. **Development of high and ultrahigh magnetic fields for magnetic resonance imaging and spectroscopy, particularly for neuroimaging and fMRI**. A common thread in my work has been the effort to exploit high magnetic fields for human studies in order to enhance the biological information content, accuracy, and resolution of imaging and spectroscopy signals. My laboratory was one of the first three academic laboratories that initiated 4 Tesla (T) human imaging in ~1990. Subsequently, justified by a large body of 4T human data and small animal experiments conducted at 9.4T, we were the first to introduce 7 Tesla for human studies in ~1999, using a magnet developed specifically for us and system development and integration undertaken by my group. This seminal effort was complemented with fundamental studies on the physics of high field imaging in the human body, development of new high field methods and instrumentation (such as parallel transmit concepts and hardware), and introduction of new data acquisition methods, to attain some of the most advanced neuroimaging capabilities. The data coming from this 7T system ultimately led to commercially produced 7T systems, 510K approval of 7T by the FDA and to the evolution of 7T as the most advanced neuroimaging and, more recently, torso imaging platform.
    a. **Ugurbil K**, Garwood M, Ellermann J, Hendrich K, Hinke R, Hu X, Kim SG, Menon R, Merkle H, Ogawa S, Salmi R. (1993). “Imaging at high magnetic fields: initial experiences at 4 T”. Magn Reson Q 9, 259-277.
    b. Vaughan JT, Garwood M, Collins CM, Liu W, DelaBarre L, Adriany G, Andersen P, Merkle H, Goebel R, Smith MB, **Ugurbil K**. (2001). “7T vs. 4T: RF power, homogeneity, and signal-to-noise comparison in head images.” Magn Reson Med 46, 24-30.
    c. Adriany G, Van de Moortele PF, Wiesinger F, Moeller S, Strupp JP, Andersen P, Snyder C, Zhang X, Chen W, Pruessmann KP, Boesiger P, Vaughan T, **Ugurbil K**. (2005). “Transmit and receive transmission line arrays for 7 Tesla parallel imaging.” Magn Reson Med 53, 434-445.
    d. Van de Moortele PF, Akgun C, Adriany G, Moeller S, Ritter J, Collins CM, Smith MB, Vaughan JT, **Ugurbil K**. (2005). “B(1) destructive interferences and spatial phase patterns at 7 T with a head transceiver array coil.” Magn Reson Med 54, 1503-1518.
4. **The Human Connectome Project (HCP)**. HCP was a major undertaking by the NIH, aimed at mapping connections in of the human brain in the mm scale in young normal adults. This project was awarded to a consortium led by the Washington University and the University of Minnesota (1U54MH091657) with David Van Essen from (Wash U) and I serving as co-PIs. My group was responsible for all the technical developments for image acquisition and reconstructions methods. Starting from developments already in

progress in my group, we were able to accomplish major advanced for image acquisition leading to the highest temporal and spatial resolution fMRI and diffusion weighted (dMRI) images of the human brain, and significant improvements in connectomics information derived from such data. These imaging approaches have redefined functional and diffusion weighted imaging. HCP accomplishments is considered a a major advance in brain sciences (http://www.nimh.nih.gov/about/director/2015/brain-awareness.shtml), and have led to numerous new HCP stle projects.

a. **Ugurbil K**, Xu J, Auerbach EJ, Moeller S, Vu AT, Duarte-Carvajalino, et al. (2013). "Pushing spatial and temporal resolution for functional and diffusion MRI in the Human Connectome Project." Neuroimage 80, 80-104. PMCID: PMC3740184.
b. Van Essen DC, Smith SM, Barch DM, Behrens TE, Yacoub E, **Ugurbil K**, WU-Minn HCP Consortium. (2013). "The WU-Minn Human Connectome Project: An overview." Neuroimage 80, 62-79. PMCID: PMC3724347.
c. Smith SM, Miller KL, Moeller S, Xu J, Auerbach EJ, Woolrich MW, Beckmann CF, Jenkinson M, Andersson J, Glasser MF, Van Essen DC, Feinberg DA, Yacoub ES, **Ugurbil K**. (2012). "Temporally-independent functional modes of spontaneous brain activity." Proc Natl Acad Sci U S A 109, 3131-3136. PMCID: PMC3286957.
d. Xu J, Moeller S, Auerbach EJ, Strupp J, Smith SM, Feinberg DA, Yacoub E, **Ugurbil K**. 2013. "Evaluation of slice accelerations using multiband echo planar imaging at 3 T." Neuroimage 83, 991-1001. PMCID: PMC3815955.

5. **In vivo magnetic resonance Spectroscopy and applications to studies in the human brain**. One of the first pioneering efforts towards using MR spectroscopy to extract biological and physiologic information non-invasively in intact biological systems was started in Bell Laboratories Biophysics group where I worked after my PhD. In this small group, my colleagues and I introduced and demonstrated the use of MR spectroscopy in intact biological systems. Many of these techniques are used by me and others to study bioenergetics of neuronal function in the human brain.

a. **Ugurbil K**, Brown TR, den Hollander JA, Glynn P, Shulman RG. (1978). "High-resolution 13C nuclear magnetic resonance studies of glucose metabolism in Escherichia coli." Proc Natl Acad Sci U S A 75, 3742-3746.
b. Brown TR, Kincaid BM, **Ugurbil K**. (1982). "NMR chemical shift imaging in three dimensions." Proc Natl Acad Sci U S A 79, 3523-3526.
c. Chen W, Zhu XH, Gruetter R, Seaquist ER, Adriany G, **Ugurbil K**. (2001). "Study of tricarboxylic acid cycle flux changes in human visual cortex during hemifield visual stimulation using (1)H-{(13)C} MRS and fMRI." Magn Reson Med 45, 349-355.
d. Mangia S, Tkac I, Gruetter R, Van de Moortele PF, Maraviglia B, **Ugurbil K**. (2007). "Sustained neuronal activation raises oxidative metabolism to a new steady-state level: evidence from 1H NMR spectroscopy in the human visual cortex." J Cereb Blood Flow Metab 27, 1055-1063.

Complete List of Published Work in MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/kamil.ugurbil.1/bibliography/45757589/public/?sort=date&direction=descending

D. ACTIVE RESEARCH SUPPORT

P41EB015894 (PI: Ugurbil) **06/01/2013 - 05/31/2018** **3.00 Calendar Months**
NIH $1,349,542
NMR Imaging and Spectroscopy

The aim of this grant is to significantly advance MR methodology and their biomedical applications in humans by developing novel image acquisition/reconstruction and engineering technologies and enabling Collaborative and Service projects to utilize these advances to investigate human organ function in health and disease.

R01MH111447 (PI: Ugurbil) **09/01/2016 – 08/31/2021** **1.80 Calendar Months**
NIH $699,938
Neurons, Vessels and Voxels: Multi-modal Imaging of Layer Specific Signals

This BRAIN initiative R01 investigates the spatial scale of neurovascular coupling and fMRI mapping signals in the brain using multiple imaging modalities in an animal model system and in humans in order to generate a detailed understanding of how neural activity generates selective vascular responses fMRI mapping signals.

UO1 EB025144-01(PI: Ugurbil) **09/28/2017 – 06/30/2022** **1.80 Calendar Months**
NIH $1,650,909

Elementary Neuronal Ensembles to Whole Brain Networks: Ultrahigh Resolution Imaging of Function and Connectivity in Humans

This project aims to develop unique technologies to usher in the next generation of MRI instrumentation, in order to study the human brain at currently unavailable resolution and detail in health and disease, and to generate a publicly available unique data for investigating of human brain function and circuitry.

2P30 NS076408 (PI: Ugurbil) 09/28/2017 – 08/31/2022 0.60 Calendar Months

Institutional Center Cores for Advanced Neuroimaging

The general aim of this proposal is to enable enable and encourage NINDS-funded research projects and investigators to integrate the CMRR's advanced instrumentation, technologies, and expertise for biomedical imaging in order to facilitate and amplify their research efforts towards fulfilling the NINDS mission.

R24 MH108315 (PI: Ugurbil) 06/01/2015 – 05/31/2020 0.12 Calendar Months

NIH $124,079

Connectome Coordination Facility

The CMRR will provide consultation and support services to the research community for the purpose of harmonizing methods and protocols with those of the HCP. The effort entails transfer for the MRI pulse sequence, harmonization of the imaging protocols, image reconstruction support, and a help desk.

UO1AG052564 (Co-PI: Ugurbil) 03/01/2016 – 02/28/2020 1.20 Calendar Months

NIH (Sub To Washington Univ) $242,434

Mapping the Human Connectome During Healthy Aging

The CMRR will optimize imaging protocols in year 1 for the consortium and provide MRI support for all consortium members in years 2-4. In addition, in years 2-4, 300 subjects (75 of whom will be followed longitudinally) will be scanned at the CMRR on a 3T Prisma. All of the data acquired will be publicly available.

UO1MH109589 (PI: Yacoub) 03/01/2016 – 02/28/2020 0.48 Calendar Months

NIH (Sub to Wash U) (Co-Inv: Ugurbil) $195,558

Mapping the Human Connectome during Typical Development

The CMRR will optimize imaging protocols in year 1 for scanning young children and adults (Ages: 8-21) for the consortium and provide MRI support for all consortium members in years 2-4. In addition, in years 2-4, 275 subjects will be scanned at the CMRR on a 3T Prisma. All of the data acquired will be made publicly available.

R01MH111413 (PI: Chen) 09/01/2016 – 08/31/2021 0.36 Calendar Months

NIH (Co-Inv: Ugurbil) $600,545

Integrated fMRI Methods to Study Neurophysiology and Circuit Dynamics at Laminar and Columnar Level

This research combines novel electrophysiology technologies and fMRI to overcome current technical barriers, and significantly advance multimodal fMRI technologies at ultrahigh fields. The research is aimed at elucidating the electrophysiological basis and neural correlates of fMRI BOLD signal at mesoscopic scale.

UO1 MH110274 (Sub PI: Elison) 09/01/2016 – 05/31/2020 1.20 Calendar Months

NIH (Co-PI: Ugurbil) $1,166,765

UNC/UMN Baby Connectome Project

University of North Caroline at Chapel Hill (UNC) and the University of Minnesota (UMN) will join forces to conduct HCP style imaging studies on 500 typically developing children between birth and five years of age, and develop novel image acquisition as well as image analysis tools capable of providing quantitative measures of early brain development. The data will be publicly available.

UO1 HL117664 (PI: Gupta) 06/01/2014 – 05/31/2018 0.12 Calendar Months

NIH (Co-Inv: Ugurbil) $1,270,369

Cannabinoid-based Therapy and Approaches to Quantify Pain in Sickle Cell Disease

The major goal of this project is to examine the mechanisms(s) that cause ongoing pain and if Cannabis-based drugs can provide analgesia to treat pain in sickle cell disease