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Probing brain tissues at the mesoscopic scale using ultra-high field magnetic resonance imaging (UHF-MRI),

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Understanding the singularity of the human brain structure and organization with respect to other species requires to go beyond the typical millimeter resolution offered by most conventional MRI scanners found in hospitals. The challenge is now to reach the mesoscopic scale corresponding to the scale of cortical columns supposed to be the relevant entities to understand and map brain networks. Increasing the static magnetic field of MRI has already proven to be useful to enhance the spatial and temporal resolutions of MRI data. Equipped with a unique platform of UHF clinical (3T & 7T) and preclinical (7T, 11.7T and 17.2T) MRI systems and after a decade of research and methodological developments, Neurospin (Frédéric Joliot Institute, Fundamental Research Division, CEA), a high field research center dedicated to neurosciences based in Paris-Saclay campus, is about to ramp-up the first clinical 11.7T MRI system in the world, in order to run into this new challenge of decoding the human brain functioning. In order to rise this challenge, most techniques have to be drastically revisited from the hardware to the image analysis pipelines. During this presentation, we propose an overview of the various methodological developments that were performed during the last decade about all aspects including magnet design, coil design, MR pulse sequence design, image reconstruction, biophysical modeling and image processing at ultrahigh field to take benefit of the increased signal to noise ratio to observe the healthy and diseased human brain at a resolution approaching the mesoscopic scale.