

Ultra High Field MRI toward Molecular Imaging & Development of a PET-MRI Fusion System

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Three main topics will be discussed; one with PET, a representative molecular imaging device, secondly, MRI which majority of current diagnostic imaging is based, and thirdly, PET MRI fusion system, a combined system which exploits both the molecular imaging capability of PET with an Ultra high resolution imaging capability of MRI.

First, PET, the modern molecular imaging device which was developed in mid 70's and widely used in modern time, i.e., detection of early cancers and other abnormality based on chemical and molecular bases. For example, many of metabolic activities in the brain as well as in the body are closely related with cancer. That is cancerous tissue are often more metabolically active. Besides the simple metabolic activity measurement, PET can detect many neurochemicals use of, often called as radioligands, such as neurotransmitter substitute, neurotransmitter receptor agonist or antagonist in the synaptic area. PET is becoming the major tool for brain's functional imaging device as neurosciences and neurological diseases grow. For example Alzheimer's, Parkinson's and other neurodegenerative diseases. One of the latest developments in PET is the research prototype known as HRRT (High Resolution Research Tomography) dedicated for brain research. It boasts resolution as high as 2.5mm fwhm.

Secondly, MRI which has been developed in the early 70's but its full utility has been since mid 80's. Now MRI became an essential imaging tool for nearly everything from small cancerous tumor detection to diagnosis of the Parkinson's. Principle of the MRI is basically the magnetic resonance phenomenon and computerized image reconstruction. Now MRI of magnetic field of 1.5T (T=10K Gauss) are common in most hospital uses, more advanced MRI are of 3.0T which is now considered as most up to date clinically useful MRI. For the research end, now 7.0T whole body MRI becoming popular and over 30 different research sites world wide have installed 7.0T and carrying out the research. Resolution and often the contrast are usually proportional to the magnetic field, therefore, 7.0T MRI are approximately 4~5 times better in resolution compared with 1.5T. Research and development will certainly continues in this field and resolution and contrast will improve as research progresses.

Lastly, PET and MRI fusion system are the one of the most advanced and complex imaging system yet developed, since the two devices are not compatible each others, that is PET is extremely sensitive to magnetic field, therefore, can not be near to the MRI devices. It is especially so for such an ultra-high field MRI system which is in the range of 3~7T or more. Currently, one of the highest end PET-MRI fusion systems is a fusion system of HRRT and 7.0T. This new molecular imaging system could image, for instance, neurochemical processes in small hippocampal area hitherto unable to image. In this case, 2.5mm fwhm PET images are superimposed onto the 7.0T MRI images which have resolution of 300 μm or less. Combination of these two, finally able to localize the metabolic activities in small subregion of hippocampus with resolution down to 300 μm .