Enabling Technology for the Dedicated Brain PET Now and for the Era of Precision Medicine

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Generic “one-design fits all” bulky bolted to the floor whole body PET scanners are highly suboptimal to image the brain (low sensitivity and poor spatial resolution). Past efforts with dedicated brain imagers were only partially successful from the clinical and marketability points of view.

In the past 5-10 years many research groups and companies around the world are intensely working on developing dedicated brain PET imagers using compact solid state sensor technologies (Silicon Photomultipliers). Examples are the efforts in Europe (Spain, Italy), USA, Japan, Korea and China. A short review of these technical efforts will be presented to illustrate the new underlying technology, novel compact open and helmet style designs and novel applications enabled by the technology.

Timing is perfect as we are approaching the era when “one-dose fits all” will not be accepted anymore. The injected dose of the imaging agent will have to be justified/calculated for each imaging task and each individual. Fortunately, due to a combination of the above recent technological breakthroughs in PET instrumentation using solid state based technology, and progress with 3D image reconstruction algorithms as well as with dynamic/kinetic analytical algorithms, it became possible to design MRI-compatible, Time-of-Flight (TOF) capable high resolution brain PET imagers with ***an order of magnitude higher sensitivity*** in brain imaging tasks than provided by the standard whole body PET scanner. In addition, with the excellent now achievable TOF resolutions of ~200 psec FWHM, an accompanying standard CT scan providing attenuation map for the PET reconstructions (and that adds to the radiation dose burden) may not be necessary. Development of still better 100 ps and below systems is in progress, further increasing sensitivity of the system. Good spatial resolution in the compact brain scanner structure requires high (few mm) Depth of Interaction (DOI performance) and new DOI techniques are providing this performance.

What is also important, that these new systems can be made portable or mobile, used in the point of care or bedside situations that was mostly impossible before. Examples are assistance with surgery, epilepsy, in stroke. These imagers are being developed as portable inserts in MRI, potentially converting any MRI scanner into a PET/MR brain imager. Brain PET scanner can be also paired with a PET/CT scanner to form a tandem brain-organ dynamic imager for simultaneous imaging of the brain (and with much better quality) and other associated organs (for example heart).

Depending on the tasks, different variants/models of the dedicated brain PET imager can be developed, with some examples such as: upright wearable robot-supported for the neuroscience applications in the study of the healthy brain, sub-mm resolution for epilepsy, low (1-10%) dose for dementia screening, TBI and mTBI diagnosis, schizophrenia, depression, stroke, imaging vulnerable subjects (children), etc, etc.