Ministry of Human Resources and Social Security

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

2019 Helmholtz – OCPC – Program

for the involvement of postdocs in bilateral collaboration projects

PART A Title of the project: Impact of Positron Range on UHF-MRI-PET for Brain Imaging

Helmholtz Centre and institute: Forschungszentrum Jülich GmbH, Institute of Neuroscience and Medicine, Medical Imaging Physics (INM-4)

Project leader: Dr. Christoph Lerche

Web-address: http://www.fz-juelich.de/inm/inm-4/EN/

Description of the project:

Positron Emission Tomography (PET) is an important, non-invasive *in vivo* medical imaging technique that provides quantitative molecular information of the distribution of a radiotracer (molecule of interest labelled with a radioactive element) administered to a patient or volunteer. PET has a million-fold higher detection sensitivity compared to other imaging modalities, as for instance Magnetic Resonance Imaging (MRI). Conversely, MRI allows for a variety of functional information using perfusion- or diffusion-weighted imaging and MR spectroscopy in addition to providing anatomical high-resolution images with excellent tissue contrast. Ultra-high field (UHF) MRI scanners have numerous advantages for detection of metabolic changes *in vivo* and their microstructural and functional consequences, including the access to metabolically relevant nuclei other than ^{1}H, such as ^{23}Na and ^{31}P. The combination of PET and MRI offers a unique opportunity to access both function and structure of the tissue, organ or organism. In neuroscience, this can add valuable information for brain architecture mapping, local metabolic activity, and receptor expression of the healthy or diseased brain, making combined MR-PET a striking tool for the brain imaging and neuroscience.

In a combined MR-PET device, there is another, incidental, advantage; the trajectory of the emitted positron is curled and therefore the effective positron range is reduced in transversal direction due to the Lorentz force induced by the large static magnetic field. The influence of the magnetic field on positron emitters and the anticipated improvement of PET image spatial resolution and image contrast in hybrid, integrated MR-PET scanners due to the confined positron trajectory has been studied in a number of papers since 1986. The best improvement was found with ultra-high magnetic fields and for radioisotope with highest β^{+}-energy. First strategies for correcting the positron range in PET images have already been proposed, e.g. integration of the positron range into the PET image reconstruction or via postprocessing. The largest image improvement was found at tissue boundaries with high differences in density and effective atomic number.

Within this project, the effect of positron range on PET images of the human brain shall be studied for different magnetic field strengths and several radioisotopes for PET, including standard and non-standard radioisotopes. Furthermore, strategies for correcting the positron range in the reconstructed PET images shall be investigated, focusing on quantification and special conditions imposed by non-standard radioisotopes and combination with high field

and ultra-high field MR imaging, i.e. anisotropy of the positron range in high magnetic fields and MR derived gamma ray attenuation maps. The effect of positron range on PET image quality shall be studied by simulations for different head PET scanner configurations and, if available, completed by measurements with dedicated PET inserts for brain imaging.

Description of existing or sought Chinese collaboration partner institute:

This post-doc project will be used to intensify the cooperation between Research Centre Jülich in Germany, and Division of Nuclear Technology and Applications in the Institute of High Energy Physics (IHEP), Chinese Academy of Sciences (CAS). The IHEP, a Chinese Academy of Sciences research institute, is China's biggest laboratory for the study of particle physics. The Division of Nuclear Technology and Applications focuses on the R&D of nuclear technology oriented by social and economic needs. It is also a platform of technology transfer for advanced accelerator and radiation technology. The division has conducted simulation research on multimodal PET/MR imaging system and Brain imaging/neuroscience with Monte Carlo method. In the past years, the two institutes have close cooperation in these fields by jointly educating talents. The successful candidate will further promote the cooperation between Jülich and IHEP on combined MR-PET device in experiment and theory.

Required qualification of the post-doc:

- PhD in Nuclear Physics, Computational Science, Particle Physics or related fields.
- Experience with Monte Carlo simulation; studies on particle interaction with human tissue; PET/MR imaging system.
- Additional skills in mechanical design (SolidWorks CAD, Auto CAD), Software Programming (C++, Linux, ROOT).

PART B

Documents to be provided by the post-doc, necessary for an application to OCPC via a postdoc-station in China, which is affiliated to a research institution like a university:

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation
- Proof of command of English language

PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 35 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team