Contribution ID: **26** Type: **Oral**

Design of the BrainPET 7T Project's UHF MRI-Compatible PET Modules based on the Hyperion III Platform

Sunday, 29 May 2022 11:00 (20 minutes)

PET-MRI provides excellent soft-tissue contrast combined with visualization of metabolic processes. Especially, brain-imaging benefits from organ-dedicated scanners providing high sensitivity and homogenous spatial resolution. The BrainPET 7T project aims to build a PET insert for human imaging with a particular emphasis on UHF MR-compatibility, imaging of non-proton nuclei, and neuroscientific studies with cognitive tasks. The system design enables a sensitivity of 12% and a spatial resolution of 1.6 mm based on point source and Derenzo phantom simulations. Here, we present the concept and implementation of the MRI-compatible PET modules used in the BrainPET insert.

The BrainPET insert contains 8 identical PET modules which employ the Hyperion III PET platform as readout electronics. 15 detector stacks with a 48 x 48 mm^2 active area are equipped with digital SiPMs (DPC 3200-22, DPC) and connected to one singles processing unit (SPU). The synchronized SPUs collect, (pre-)process, and send the data to a central data acquisition architecture.

For every PET module, three highly-integrated Mounting & Cooling (M&C) structures host five detectors each, resulting in an axial FOV of approximately 25 cm. The M&C structure is a composite consisting of glass-reinforced plastic for mechanical stability and a copper inlay featuring liquid cooling. As the copper inlay is not required for mechanical stability, we were able to highly structure the electrically conductive area to reduce Eddy currents induced by the MRI's gradient switching. All detector stacks connect to the M&C structure utilizing a kinematic mounting system, ensuring a precise positioning while preventing strain energy to be inserted into the system.

A carbon-fiber-reinforced plastic housing encloses all components reducing interferences between MRI scanner and PET electronics. A sizeable removable cover of the housing allows installation and maintenance of all components.

Primary author: Mr MUELLER, Florian (Department of Physics of Molecular Imaging Systems, Institute for Experimental Molecular Imaging, RWTH Aachen University)

Co-authors: Dr SCHUG, David (1 Department of Physics of Molecular Imaging Systems, Institute for Experimental Molecular Imaging, RWTH Aachen University, Aachen, Germany 2 Hyperion Hybrid Imaging Systems GmbH, Aachen, Germany); WEISSLER, Bjoern (1 Department of Physics of Molecular Imaging Systems, Institute for Experimental Molecular Imaging, RWTH Aachen University, Aachen, Germany 2 Hyperion Hybrid Imaging Systems GmbH, Aachen, Germany); RADERMACHER, Harald (RWTH Aachen University); KRUEGER, Karl; YIN, Laiyin (RWTH Aachen University); NADIG, Vanessa (RWTH Aachen University); MAZUR, Adalbert (Scientific Workshop University Hospital RWTH Aachen, RWTH Aachen University, Aachen, Germany); HONNE, Axel (Scientific Workshop University Hospital RWTH Aachen, RWTH Aachen University, Aachen, Germany); COLLIENNE, Juergen (Central Institute of Engineering, Electronics and Analytics 1, Forschungszentrum Jülich, Germany); LENNARTZ, Manfred (Central Institute of Engineering, Electronics and Analytics 1, Forschungszentrum Jülich, Germany); GRUNWALD, Dirk (Central Institute of Engineering, Electronics and Analytics 1, Forschungszentrum Jülich, Germany); CHOI, Chang-Hoon (Institute of Neuroscience and Medicine 4, Forschungszentrum Jülich); FELDER, Joerg (Affinity Imaging, Jülich, Germany); SCHEINS, Juergen (Institute of Neuroscience and Medicine 4, Forschungszentrum Jülich); NIEKAEMPER, Debora (Institute of Neuroscience and Medicine 4, Forschungszentrum Jülich); LERCHE, Christoph (Institute of Neuroscience and Medicine 4, Forschungszentrum Jülich); SHAH, N. Jon (Institute of Neuroscience and Medicine - 4, Forschungszentrum Juelich); SCHULZ, Volkmar (RWTH Aachen University, Hyperion Hybrid Imaging Systems, Fraunhofer MEVIS)

Presenter: Dr SCHUG, David (1 Department of Physics of Molecular Imaging Systems, Institute for Experimental Molecular Imaging, RWTH Aachen University, Aachen, Germany 2 Hyperion Hybrid Imaging Systems GmbH, Aachen, Germany)

Session Classification: PET/MR and SPECT/MR systems and applications

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