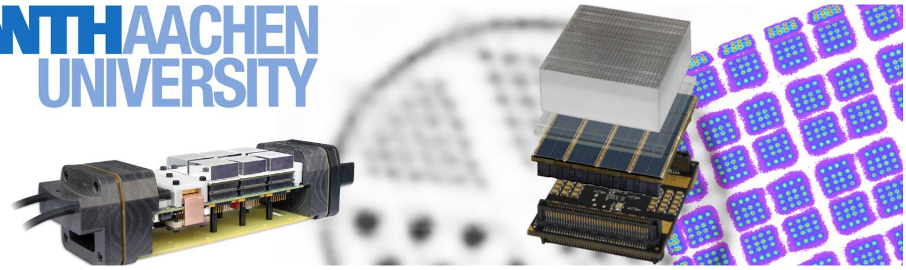

Research focus of the department of "Physics of Molecular Imaging Systems" (**PMI**) is on exploring the physical limits of current and future molecular imaging technologies. These areas range from simulations of new detector concepts, hardware prototypes, high speed data processing, image reconstruction algorithms and applications using our research imaging prototypes. Our group consists of students and researchers from different disciplines: physics, engineering, computer science and medicine. PMI is part of a large international network with a close link to industry, particularly to Philips Research.

Master's Thesis: Development of a Advanced Monolithic PET Detector Block

In Positron Emission Tomography (PET) imaging (Fig. 1), a patient or animal is injected with a radioactive substance emitting positrons during decay. The positron annihilates with an electron from the subject's body, thus producing two photons which propagate through the body in opposite directions. These photons are detected outside the body using a ring of PET detectors. These PET detectors are typically scintillators, converting the 511 keV gamma photon to a high number of optical photons, which are detected by underlying photosensitive detectors.

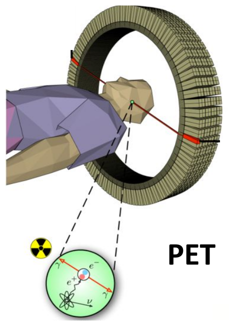

Fig. 1: In PET, two 511 keV gamma photons from a positron-electron annihilation have to be detected and correlated.

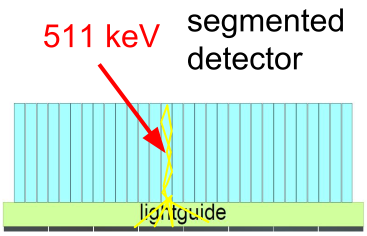

Fig. 2: The scintillation light caused by a gamma particle is spatially confined in a pixelated detector. The scintillator segments are isolated from each other by reflective foils.

Traditionally, PET scintillators are segmented into compartments to optically separate the scintillators from each other (Fig. 2). To localise the element in which the gamma interacted, the light distribution that is measured by photo-sensitive detectors is evaluated [1]. The spatial resolution of a segmented gamma detector is limited by the size of the elements and is often limited to two dimensions. For very finely segmented scintillators that offer a high spatial resolution the filling fraction is disadvantageous, as the material budget for the reflective foils grows compared to the scintillator material. Furthermore, the production costs for high-resolution scintillator arrays are very high.

Monolithic scintillator blocks, on the other hand, do not incorporate a segmentation. The point of interaction of the gamma can be reconstructed in all three dimensions from the light distribution measured by multiple photodetectors [2]. In a simple arrangement, the monolith is a cuboid and the photodetectors are coupled to one side only (Fig. 3). Our group developed an optical simulation environment using GEANT4, which shall be used to investigate the potential of more advanced monolithic scintillator configurations and placement of photodetectors. The candidate will use the toolkit to simulate monolithic detector blocks with non-cuboid geometries and optimize the photodetector placement. In a next step, promising detector concepts shall be constructed and the simulations validated by experiments using the PET platform developed in our group [3].

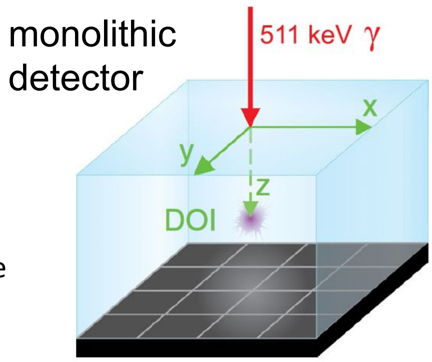

Fig. 3: A cuboid, monolithic detector block concept. (reprinted from Van Dam, H. T. et al. (2011). "A practical method for depth of interaction determination in monolithic scintillator PET detectors". Phys. Med. Biol., 56(13), 4135–4145. doi:10.1088/0031-9155/56/13/025)

[1] D. Schug *et al.*, 2015, *IEEE TNS* 62 3 669, doi: 10.1109/TNS.2015.2420578
[2] G. Borghi *et al.*, 2016, *Phys. Med. Biol. 61 4904*, doi: 10.1088/0031-9155/61/13/4904
[3] B. Weissler *et al.*, 2015, *IEEE TMI 34 11 2258*, doi: 10.1109/TMI.2015.2427993

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