NIAM3 is a compact implementation of the NIAM (Non-Invasive Arterial Monitor) system aimed at quantitative measurement of the arterial input function for use in PET. A driving force behind the development of NIAM has been to facilitate clinical research trials quantified PET imaging and overcome the challenges imposed by invasive arterial sampling. Early NIAM systems were based on more traditional PMT technology and VME readout. As a consequence they were rather bulky and difficult to maneuver in patient settings and feedback gained during trials has motivated the development of a more compact device. The novel approach reported here exploits the attractive attributes of silicon photomultipliers (SiPM), including high gain and small size, which make them an ideal choice for next generation PET imaging systems. Furthermore, insensitivity to the adverse effects of magnetic fields will also drive their application in PET/MRI.

Experimental Setup

Each NIAM detector module is based on an array of 144 x 3.4 mm wide and 20 mm deep LYSO crystals (Crystal Photonics) arranged in a square matrix and coupled to a SensL Matrix9 SiPM. GEANT4 modelling of this arrangement has been used to ensure optimal light coupling and sharing. GATE simulations of NIAM also identified that a six block geometry was preferred for spatial uniformity and improved spatial resolution. A prototype NIAM3 system has now been built and consists of 6 NIAM SiPM detector modules, arranged in a hexagon with a bore of 80mm, which results in an active field of view of 80 mm². Shadow shielding of the detectors with lead has been implemented to minimize background counts from the trunk of the patient.

To allow real-time operation in list mode, a customised readout strategy has been developed. Image reconstruction is performed using the iterative List-Mode Maximum Likelihood Expectation Maximisation (MLEM) reconstruction algorithm [4,5].

Results

To investigate the characteristics of the NIAM3 system such as sensitivity and linearity, an arterial wrist phantom was constructed using tygon tubes (inner dia. 3 mm, outer dia. 7 mm) containing FDG separated by an identical tube of water.

Count rate sensitivity limits the minimum acquisition time and is primarily determined by geometry and the efficiency of both the detector and the triggering circuit. Sensitivity and linearity were investigated with samples of known concentration. The sensitivity of NIAM3 is 14 cps/kBq, which represents a 3-fold increase on the original proof of concept [6].

Conclusions

The performance parameters of NIAM now approach that of pre-clinical imaging systems and will find application in many other areas, including targeted tumour and translational imaging programs. Preparation for clinical trials are currently underway.

References