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#09-118 New probe for the improvement of the Spatial Resolution in total-body PET (PROScRiPT)

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The development of new PET (Positron Emission Tomography) scanners with improved performance is still an important line of research in nuclear medicine. One current line of research in nuclear medicine is the study of a total-body scanner, the development of which would represent an improvement on the current features of PET scanners. Currently, the typical spatial resolution of the reconstructed PET images is between 4 and 6 mm. The limitation in spatial resolution is a result of the detector module design, the positron range and the non-collinearity of the detected photons. Using smaller detector modules in PET scanners would improve the spatial resolution but would worsen the sensitivity. For this reason there have been studies suggesting the use of PET probes. Such probes would improve spatial resolution without compromising the scanner sensitivity.

The use of a PET probe has been studied in several research groups with a view to improving the spatial resolution. A PET probe consists of a small detector that operates in temporal correlation with a PET scanner (by means of the scanner electronics or with rear signal processing). In this way, one of the annihilation photons interacts with the PET scanner and the other one with the probe, which has much better spatial resolution than the scanner. The fact that the PET probe can be positioned in the whole field of view (FOV) of the PET scanner is of particular interest since the probe increases the spatial resolution of a specific region/lesion of the patient's body.

The suitability of a PET probe based on scintillation crystals and silicon photomultipliers (SiPM) has been studied. The functioning of the probe will be tested in a Preclinical Super Argus PET/CT scanner for small animals.

Preliminary GATEv8.2 simulations of the probe and the Preclinical Super Argus PET/CT have been performed showing promising results. The simulated setup consisted of a PET with 4 rings and 24 modules per ring, with each module containing an array of 13x13 scintillation crystals (GSO and LYSO phoswich). The probe, consisting of a continuous scintillation crystal (LYSO) of 25.8x25.8x5 mm3, was positioned at 4 mm from a small Derenzo-like phantom which was in turn positioned in the centre of the field-of-view of the scanner. The small Derenzo-like hot-spot phantom, contains an activity concentration of 0.108 mCi/cc and has several inserts measuring 4.8, 4.0, 3.2, 2.4, 1.6 and 1.2 mm in diameter. The coincidence time window for the simulation was set to 2 ns. Images were reconstructed using a MLEM code and all the reconstructions were stopped at the 5th iteration. A reconstructed image of the Derenzo-like phantom was obtained for three cases: events in which there were temporal coincidences between any detector in the setup, events in which there were temporal coincidences between the scanner detectors and events in which at least one of the detectors involved in the temporal coincidence was the probe. The obtained results show that for the case in which there was coincidence between the scanner and the probe, the spatial resolution improved with respect to the other two cases.

Regarding the hardware involved in the project, the probe is being readout by the PETsys system, a commercial time-of-flight PET system. The system provides the digitalised signal of 64 channels per detector and has a high time resolution (time binning 20 ps). A set of calibration measurements with different monolithic crystals (LaBr3, CeBr3 and LYSO) of 25.8x25.8x5 mm and two Hamamatsu S13361-350AE-08 MPPCs (pixel pitch 25 μm and 50 μm) have been performed. The results show a better linearity of the photo-peak position with respect to the feeding voltage and a more stable energy resolution versus feeding voltage for the MPPC with 25 μm pitch. An energy resolution of 6.3% for the 511 keV energy peak of Na22 was measured at 20oC with the LaBr3 crystal.

In conclusion, the GATEv8.2 simulations show the capability of the probe to improve spatial resolution. Furthermore, tests carried out with the PETsys system show it to be a good candidate for the probe electronics.

In future work, further simulations with the probe in a total-body PET scanner will be performed. In addition, measurements in time coincidence with the probe and the scanner will be acquired and reconstructed.

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