Nicola Belcari

Short Biography:

Nicola Belcari is Associate Professor at the Department of Physics "E. Fermi" of the University of Pisa. He has been conducting his scientific research in the field of Medical Physics since the year 2000. His activity has been mainly focused on the development of new radiation detectors and their application to in-vivo molecular imaging. These applications have been focused on the construction of positron emission tomography (PET) systems dedicated to pre-clinical imaging (PET/CT), brain imaging (PET/MR) and monitoring of hadrontherapy treatments. In the years 2018-2021, he led a project for the development of next-generation AI-based TOF-PET detectors (UTOFPET). He is also the founder of the start-up IRIDAE s.r.l.

Abstract:

TOF-PET detectors based on monolithic scintillators coupled to matrices of SiPMs have the potential to provide beyond-state-of-the-art spatial resolution performance. However, this solution was typically not considered the best solution for providing excellent timing performance. Approaches based on Neural Networks have largely contributed to reaching the best spatial resolution. Still, the extraction of high-resolution timing information requires the extraction of many timestamps, typically one per SiPM element. This makes a non-multiplexed readout scheme necessary with the consequence of many output signals to be processed in real-time. To solve this issue and make monolithic crystals suitable for time-of-flight PET we have developed a data acquisition framework capable of acquiring and processing up to 256 channels in real-time with a novel algorithm for estimating simultaneously and synergically the 4D event position coordinates (x, y, depth and time). The algorithm is based on a neural network (NN) and is trained with both experimental and Monte Carlo-generated data. The NN has a computational complexity and a memory footprint low enough to allow a per-detector, real-time hardware implementation in modern, low-cost FPGAs, GPU's or TPU's. As examples, the results obtained with a 51.8 x 51.8 x 12 mm3 LYSO crystal (event positioning precision of 0.8 mm, a DOI of 1.4 mm, a CTR of 150 ps and an energy resolution of 11%) are presented together with a feasibility study for the use of BGO in whole body TOF-PET. Futuristic implementation of on-chip analog neural networks capable of extracting spatial information from monolithic crystals is also presented.