Matrix-PET: A novel PET detector concept based on large blocks of organic scintillators

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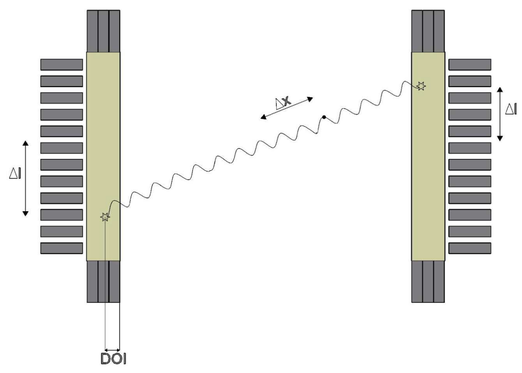
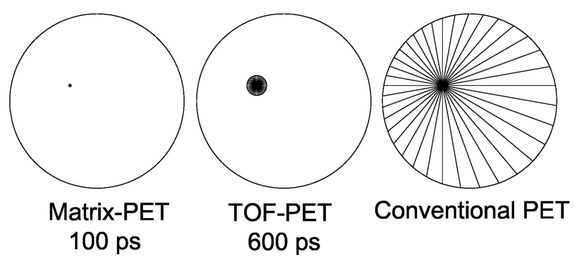
Matrix-PET is a novel detector solution for the Positron Emission Tomography. It is one of the two methods which is being developed at present at the Jagiellonian University in Cracow [1]. The detector idea is a subject of a patent application [2]. Novelty of the concept lies in using the large and thick organic scintillators blocks as a detector of gamma quanta instead of crystal scintillators used in current commercial PET scanners.

Time-of-Flight (TOF) method with detector made of organic plastic scintillators

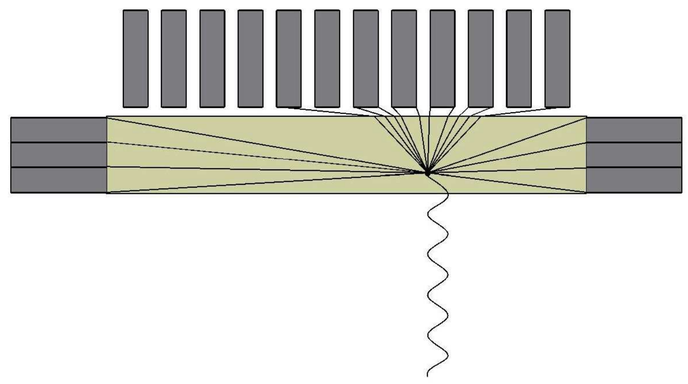
Using organic scintillators as a detector of gamma quanta in Positron Emission Tomography is a novel concept. Organic plastic scintillators are characterized by an excellent time resolution. They allow to obtain the time resolution better than 100 ps compared to 600 ps achievable in current TOF-PET scanners. This solution would also enable effective usage of the TOF method permitting the determination of the annihilation point along the Line-of-Response (LOR) based on the time difference in which the gamma quanta reach the different scintillation plates. Schematic view of the Matrix-PET detector is shown below in the left panel. High accuracy of TOF determination may significantly improve the sensitivity (image contrast), which is inversely proportional to the time resolution and directly proportional to the size of the examined object [3]. The TOF reconstruction reduces the noise propagation along the LOR during the reconstruction. Pictorial illustration of the benefit of TOF resolution in the image formation is shown below in the right panel.



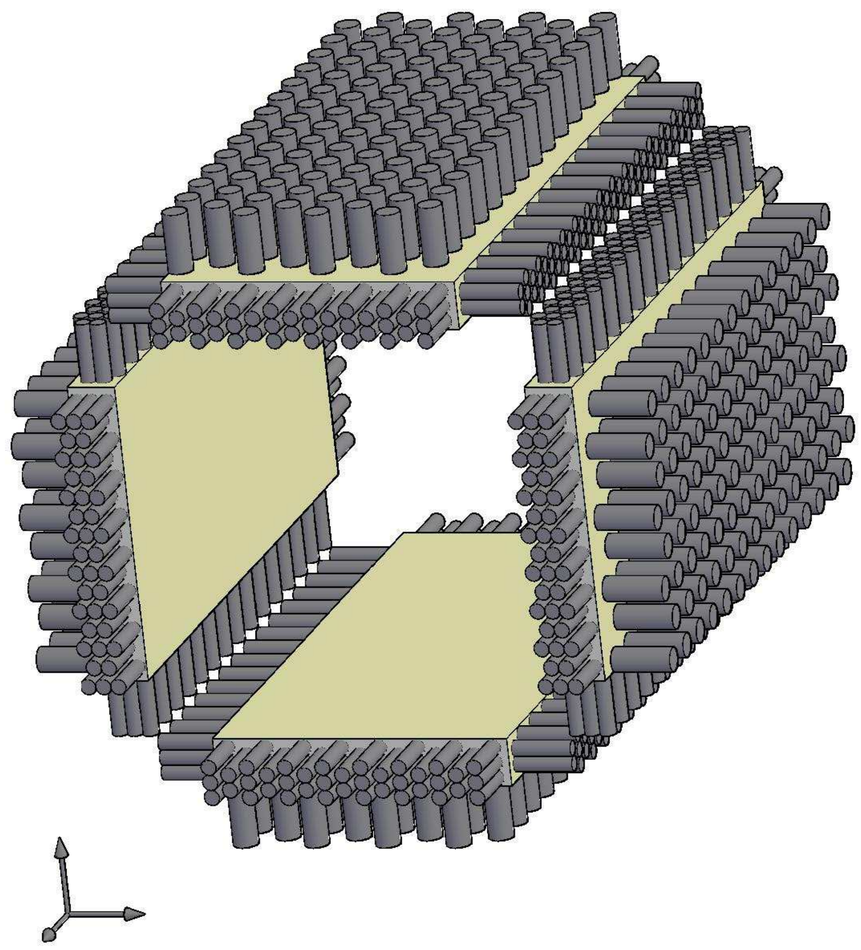


Depth-of-Interaction

The organic plastic scitillators have not been considered as potential sensors for PET detector so far due to their low density and small atomic number of elements constituting the material, which corresponds to small probability of gamma quanta detection. In the presented solution, in order to increase this probability, thick block of scintillator will be used.



Even though the single detection block will be large, the proposed concept of Matrix-PET detector will allow to determine the depth of interaction. Depth at which gamma quantum has been absorbed will be determined based on amplitudes distribution of signals from left-right and front-rear photomultipliers. Section of scintillator plate with photomultipliers is shown above.



Matrix-PET concept

One of the possible arrangement of scintillation plates for the diagnostic chamber of matrix-PET is shown in the picture on the left. The concept of Matrix-PET join advantages of time-of-flight method used for determination of the annihilation point along the line-of-response and overcomes a low detection probability of gamma quanta by usage of thick blocks of scintillator and large geometrical acceptance of the diagnostic chamber.
The coordinates of interaction point within the plane of the plate can be reconstructed based on the distribution of the times and amplitudes of signals from photomultipliers surrounding the plate. This method allows to achieve a time resolution which is not affected by the deformation of light pulses due to reflections at scintillators surfaces.

References:

[1] P. Moskal et al., Bio-Algorithms and Med-Systems 7 (2011) 73.
[2] P. Moskal, Patent applications: PCT/PL2010/00061 (2010).
[3] J. S. Karp et al., J. Nucl. Med. 49 (2008) 462.