POLYMER SCINTILLATOR DETECTORS FOR TOF-PET WITH LARGE LONGITUDINAL FIELD OF VIEW

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In this contribution we present a concept of the large acceptance detector systems based on the organic scintillators which in the future may allow for simultaneous diagnostic of large fraction of the human body. Novelty of the concept lies in employing predominantly the timing of signals instead of their amplitudes. The time resolution obtainable with plastic scintillators may be better than 100 ps [1] also for large detectors [2], and plastic scintillators can be produced easily in variety of shapes and dimensions.
One of the investigated detector concepts [3, 4] (called strip-PET) is shown schematically in Fig. 1. The strip-PET test chamber may be built from strips of organic scintillator forming a cylinder. Light signals from each strip are converted to electrical signals by two photomultipliers placed at opposite edges of the strip. The time difference between signals from both ends of the strip is used in order to determine the impact position of the gamma quantum and the time of the interaction of the gamma quantum in the strip is calculated as an arithmetic mean of the times measured on both edges of the scintillator. In the thin plastic scintillator strips the light signal propagates at about one-half of the speed of light in vacuum (c/2). Thus for the FWHM (Δt) equal to 70 ps the resolution of the position determination along the scintillator strip would amount to FWHM(Δl) $\approx$ 0.5 cm and the resolution in the determination of the annihilation point along line-of-response would be equal to FWHM(Δx) $\approx$ 0.7 cm. In particular, the last feature makes the solution very promising.
The plastic scintillators were so far not considered as potential sensors for PET detector due to their low density and small atomic number of elements constituting the material. The probability that two annihilation quanta react independently in *e.g.* 2.5 cm thick layer is about 16 times smaller for the plastic detector than in the detector made of LSO crystals. However, the aforementioned detector concept allows to compensate for the low efficiency. Mainly because: i) In the 3D mode the geometric acceptance of *e.g.* one meter long chamber will increase on average by a factor of about five in the comparison to the present PET detectors. This feature in combination with the five times larger longitudinal field of view causes that about 25 times more pairs of annihilation quanta will reach the detectors. Thus, the signal rate of an individual photomultiplier will be similar as in the currently produced PET scanners, but signals will be more than ten times shorter; ii) Improvement of TOF resolution from ~600 ps to ~70 ps would improve

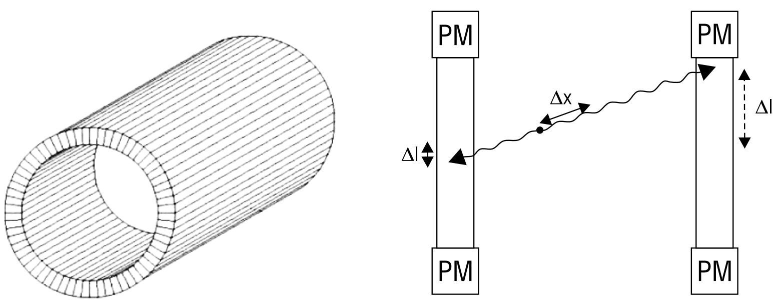

Fig. 1. (left) Scheme of the strip-PET diagnostic chamber. This solution permits for extension of the size of the scanner without a significant increase of costs. (right) Pictorial description of strip-PET concept. The hit position versus the center of the scintillator (Dl) is determined based on time difference measured on both sides of the scintillator strip, and the position (Dx) along the line-of-response is determined from time difference measured between two modules

the signal to noise ratio by a factor of about eight [5]. These two effects would compensate the smaller efficiency, which in addition can also be increased by using several layers of the cylinder. Additionally: a longitudinal field of view would be more than five times larger with respect to present PET detectors allowing for imaging of the head and whole torso simultaneously. In the case of current PET scanners such image requires performance of ten independent measurements. Thus, for the whole body examination with such large detector, while leaving the current dose of radio-pharmaceutical unchanged, one can gain another factor of ten on statistics of registered events. More detailed description of the strip-PET concept and its comparison with the present state-of-art solutions, as well as the second new detector concept [3, 4] which gives a possibility for measuring the depth of interaction (DOI), will be presented and discussed.

References

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