# Strip-PET: Concept of TOF-PET scanner based on polymer scintillator strips

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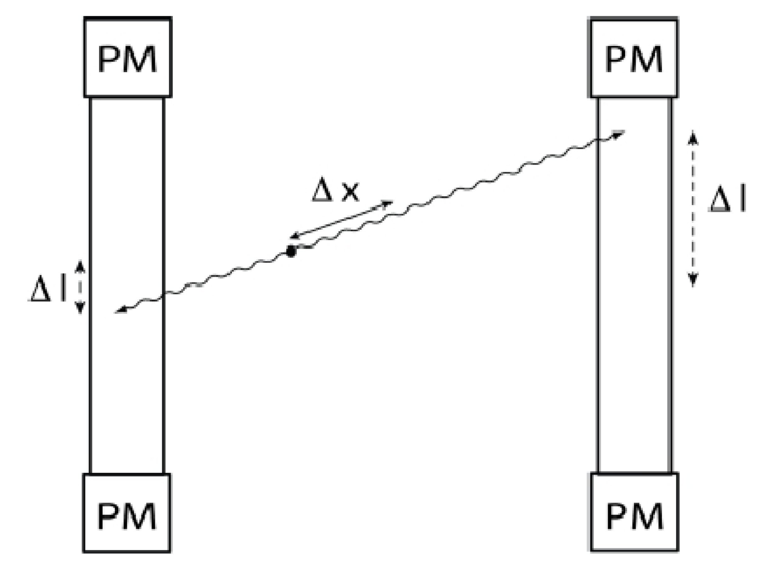
## ABSTRACT

The aim of the poster is to present an idea of a new PET scanner based on strips of polymer scintillators arranged in a large acceptance detector system which may allow a simultaneous diagnostic of a large fraction of human body. Novelty of the concept lies in employing predominantly the timing of signals instead of their amplitudes and using polymer scintillators instead of crystals to detect radiation.

## PRINCIPLES OF OPERATION




The proposed solution will allow for the determination of position and time of the reaction of the gamma quanta based on the time measurement. The hit position versus the center of the scintillator (Δl) is determined based on time difference measured on both sides of the scintillation strip. The time at which gamma quantum hits the module can be determined as an arithmetic mean of times measured on both sides of the module. Position (Δx) along the line of response is determined from time difference between two modules [1].

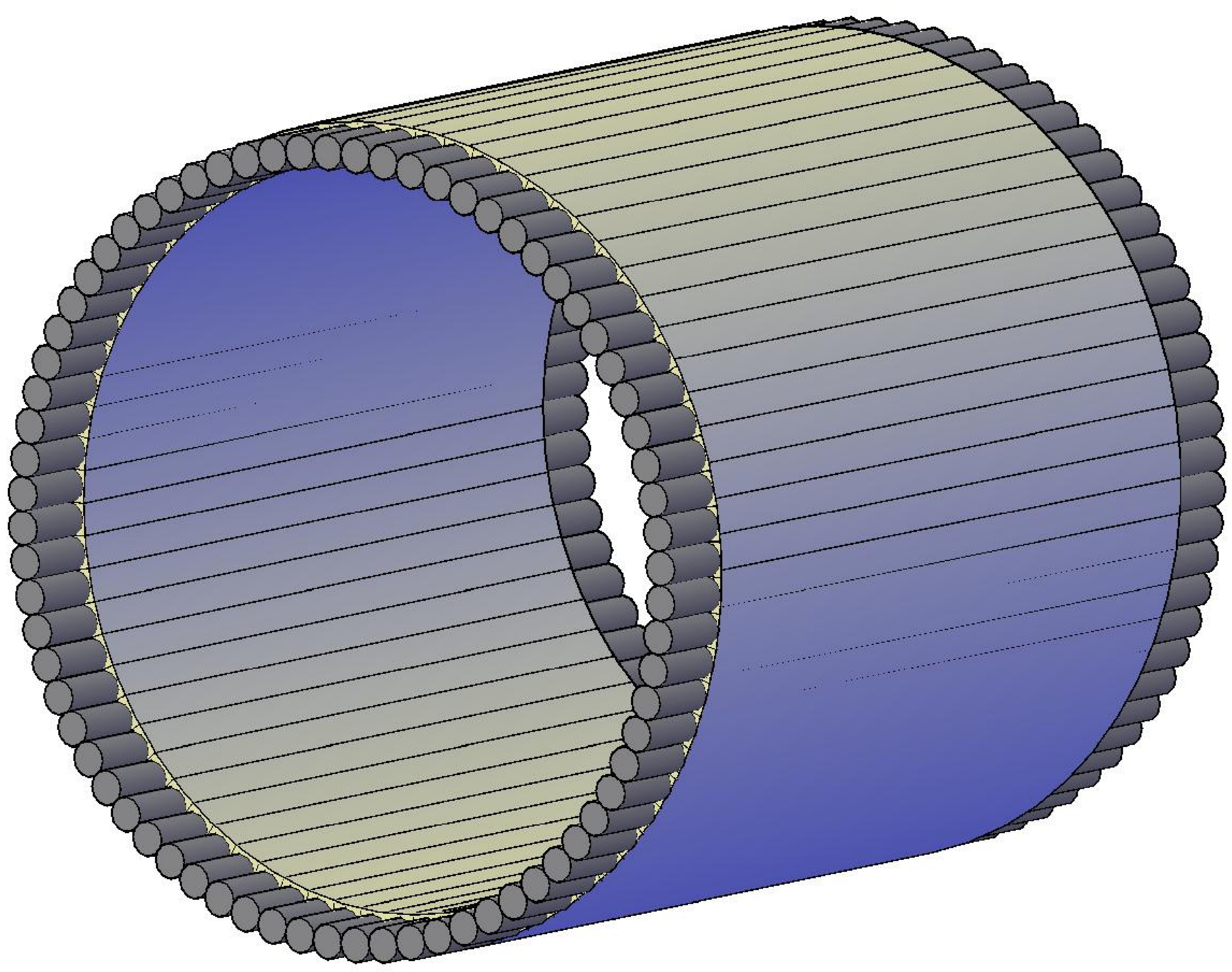


Fig. 1. Example of the Strip PET diagnostic chamber. Patient would lie inside the barrel, along scintillator strips.

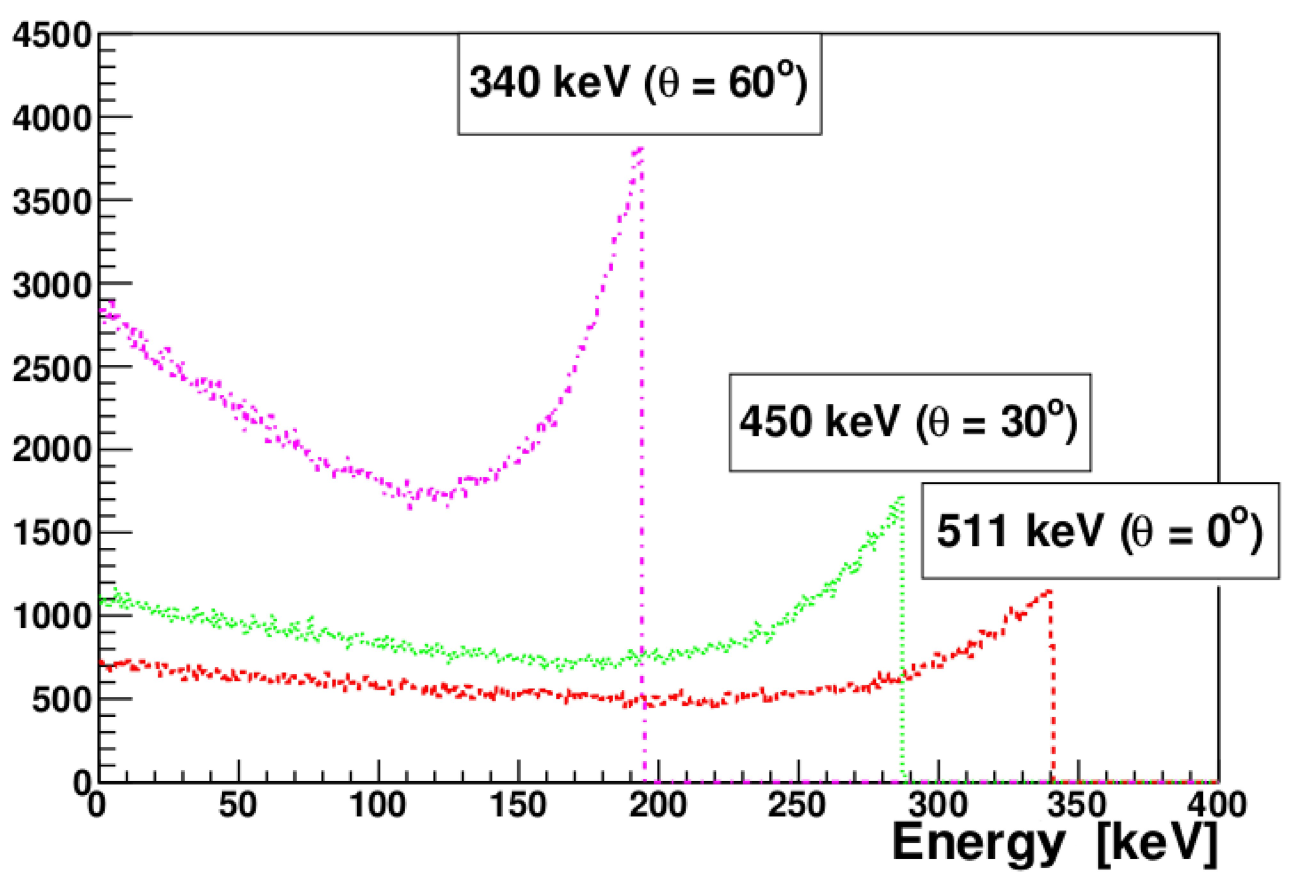



Fig. 2. Energy distribution of electrons scattered in the Compton effect by gamma quanta with an energy shown in the plot. The distributions were made without taking into account the energy resolution, which for the strip detector readout on both sides ammounts to about 18% (compared to LSO blocks which energy resolution is about 12%).

## STRIP PET

Detection chamber of PET made of polymer scintillators will be formed from strips of detectors as shown in Fig. 1 [1]. Scintillation light from both sides of each strip is converted into electric signal by photomultipliers. In case of crystal detectors for reconstruction one uses events from photoelectric effect, but in polymer scintillators probability for this phenomenon is negligible due to their low density (1.03 g/cm$^3$) and small atomic number of constituents (mainly carbon and hydrogen).

Still it is possible to use events related to Compton effect inside the detector. The maximum energy deposition of electrons from the Compton edge is equal to about 340 keV. Thus Strip PET with energy threshold of 200 keV will reduce background due to the scattering of gamma quanta in the body of a patient to the same extent as it is in the currently used tomographs which typically use the low energy threshold of about 350 keV [2]. In Fig. 2 we show Compton scattered electron energy distributions for the energy of gamma quanta reaching the detector without scattering in the patient's body, after the scattering through an angle of 30 degrees and an angle of 60 degrees.

The probability that two annihilation quanta react independently in 2.5 cm thick layers is 16 times smaller for the polymer detector than in the detector made of LSO crystals. Hovewer, the detector with a polymer scintillator chamber with a lenght of 1 m would have many advantages to compensate for lower density [3]:
- geometric acceptance will increase by a factor of 5,
- thanks to fast signals, TOF can be improved from 600 ps to 70 ps (factor of 8);
- longitudinal field of view will increase by factor of 10, increasing statistics and decreasing systematics errors when conducting a whole body scan;
- improved time resolution will enable reduction of random coincidences;
- this solution can be integrated with NMR or CT;
- several layers of strips could be placed around a patient to improve interaction probability.

## REFERENCES

[1] P. Moskal, Patent Application No: P 388 555 [WIPO ST 10/C PL388555] (2009), PCT/PL2010/00062 (2010).
[2] John L. Humm, Anatoly Rosenfeld, Alberto Del Guerra, "From PET detectors to PET scanners", Eur. J. Nucl. Med. Mol. Imaging Vol. 30, No. 11. (2003), 1574-1593.
[3] P. Moskal, S. Niedzwiecki, M. Silarski, J. Smyrski, J. Zdebik, M. Zieliński, "Novel detector systems for the Positron Emission Tomography", Bio-Algorithms and Med-Systems, suplement No. 1, Vol. 6, No. 12 (2010), 142.

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