TOT method for the disentanglement of photons in Positron Annihillation Lifetime Spectroscopy

S. Sharma,[1*] on behalf of the J-PET collaboration

[1]*Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, 30-348, Cracow*

The Jagiellonian Positron Emission Tomograph (J-PET) is the first PET built from plastic scintillators [1-5]. It is designed to studying the properties of positronium atoms and their implications for the medical imaging as well as in discrete symmetries tests [6-8]. In order to take advantages of the fast signals and low pileups in plastic scintillators the Time-Over-Threshold (TOT) method is adopted instead of measurement of charge as a response to energy deposition. The application of TOT method enables the fast signal processing reducing significantly signal acquisition dead time in comparison to crystal scintillator and providing the compactness of signals readouts. The signals are recorded using a Multi-Voltage Threshold mezzanine (MVT) board to probe signals at four fixed thresholds in voltage domain (within the accuracy of 20 ps RMS) which are based on Field Programmable Gate Arrays (FPGA) [9-10] .

In plastics, the photon interacts via Compton scattering depositing part of its energy and impede in identifying the exact energy of the interacting photons originating from the direct annihilation ($e^+e^- \rightarrow 2\gamma$) or from various possible decays channels of Positronium atoms (para-Positronium, orho-Posistronium, pick-off process). To use the potential of the TOT technique, an algorithm was developed for tagging the photons of different energies. Furthermore, a detailed analysis was performed to establish the relationship between TOT and energy deposition in a single interaction of photons based on the scattering angle via registration of primary and scattered photon positions. Results from the analysis will be presented and discussed.

References

[1] P. Moskal et al., Nucl. Instr. Meth. A 764, 317 (2014)
[2] P. Moskal et al., Nucl. Instr. Meth. A 786, 105 (2015)
[3] P. Moskal et al., Phys. Med. Bio. 61, 2025 (2016)
[4] S. Niedzwiecki et al., Acta Phys. Pol. B 48, 1567 (2017)
[5] P. Kowalski et al., Phys. Med. Bio. 63, 165008 (2018)
[6] P. Moskal et al., Acta Phys. Pol. B 47, 509 (2016)
[7] P. Moskal et al., Phys. Med. Biol. 64 , 055017 (2019)
[8] B. C. Hiesmayr and P. Moskal Scineitif Reports 7, 15349 (2017)
[9] M. Palka et al., Jour. of Instr. 12, P08001 (2017)
[10] G. Korcyl et., IEEE Trans. Of Med. Imag. 37, 2526 (2018)

*Corresponding author, Email: sushil.sharma@uj.edu.pl