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J-PET: a new experimental facility for studies of discrete symmetries in charged leptons sector

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First studies of discrete symmetries in purely leptonic systems started several decades ago and led to the discovery of weak interactions. Nowadays a positronium is considered as a fine probe into this subject, due to the fact that it is the lightest matter-antimatter system and at the same time an eigenstate of the C and P operators.
The Jagiellonian Positron Emission Tomography (J-PET) collaboration works on developing its new experimental program focusing on using large-acceptance detector of gamma quanta originating from positronium decays [1,2]. The experimental apparatus consists of 192 plastic scintillators read out from both ends with vacuum tube photomultipliers. Signals produced by photomultipliers are probed at four levels [3] in the amplitude domain and digitized on 8 FPGA based readout boards in triggerless mode [4]. In order to The energy deposition inside detection modules is determined based on the TOT (Time Over Threshold) response. Using the TOT technique, as a measure of energy loss instead of charge integration methods, significantly reduces system deadtime. This is especially crucial in case of J-PET, built out of plastic scintillators producing very fast light pulses. The drawback in adopting this technique lies in the non-linear correlation between input energy loss and TOT of the signal, which has been already characterised [5]. Additionally whole system calibration can be performed on the same data which is used to study discrete symmetries [6] which increases time which can be delegated to proper data taking.
It was observed experimentally that C-symmetry is violated in weak interactions and the best limit of the C symmetry violation in the electromagnetic interaction was set with the $\pi 0 \longrightarrow 3\gamma$ decays which amounts to branching ratio of $(3\gamma/2\gamma)$ equal to $3.1 \times 10{-}8$ at 90% C.L [7]. Experimental test of C-symmetry in positronium decays was performed by Mills and Berko (1967) [8] and the best limit was set for $1^S_0 \longrightarrow 3\gamma$ which amounted to $2.6 \times 10{-}6$ at 68% C.L.
In the scope of this presentation a description of measurements performed in order to test C-symmetry [9] will be discussed and initial results from the studies performed with J-PET detector with small detection chamber will be shown.

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Collaboration

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