Development of a $PbWO_4$ detector for single-shot positron annihilation lifetime spectroscopy at the GBAR experiment

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The GBAR experiment plans to produce anti-hydrogen atom and ion by anti-proton beam collision with ortho-positronium (o-Ps) [1]. A slow positron beam line producing short intense positron pulse has been developed to produce an o-Ps cloud with high density (up to 10^{12} o-Ps/cm^3) inside a cavity shaped target which is required to produce anti-hydrogen ions. To measure the cross-section of anti-hydrogen atom and ion, precise measurement of o-Ps density is important in order to reduce systematic uncertainty.

A fast detector composed of $PbWO_4$ crystal and a photomultiplier tube (PMT) has been developed to measure the intensity of positron beam and density of the o-Ps cloud. This type of detector assembly has proved having good time resolution in a previous study [2]. With a few photo-electron detection per 511keV γ-ray, not only large dynamic range can be achieved but also calibration of a single γ-ray signal is feasible to measure absolute efficiency. A Na-22 radioactive source has been used for energy calibration, for measurement of the detection efficiency and time response.

To achieve precise measurement, a method to take account of Compton background has been developed to reduce a bias in positron beam intensity and o-Ps density. To reduce a systematic uncertainty from mobility of o-Ps with angular spread, a simulation based on Geant4 package [3, 4] has been developed. A method to measure the angular spread has been developed based on simulation.

References

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