3rd Jagiellonian Symposium on Fundamental and Applied Subatomic Physics



Contribution ID: 30

Type: talk

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Wednesday, 26 June 2019 11:35 (15 minutes)

Design of a Novel Compact Detector based on the BGO and SiPM for Ortho-Positronium Physics

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Positronium decay research is one of the sensitive probe to discover new physical phenomenon. Because of the pairing system of electron (particle) and positron (antiparticle), we can study reactions which is forbidden by standard model. The reported positronium decay systems were composed of positron trigger and gamma detection parts. The trigger part is usually coupled to an optical fiber and the photomultiplier tube (PMT). The optical fiber trigger efficiency degrades due to significant scintillation light loss. Therefore, we designed a novel compact detector that directly collects scintillation light. In general, the size of the PMT is relatively large, so a silicon photomultiplier (SiPM) was used to make compact trigger part for direct collection of scintillation light. In this research, the trigger part consists of plastic scintillator coupled directly to single channel SiPM to obtain the positron's signal from the center of the detector. The trigger part is surrounded by the gamma detection part with an array of 14×14 BGO scintillators are coupled with 7×7 arrangement of 2×2 arrays for a total of 14×14 SiPMs. The designed frame and grid are used to support BGO scintillators and SiPMs. We obtained pretest data of a positron trigger signal and a gamma energy spectrum of 22 Na and 137 Cs radioactive sources for the novel compact detector. The detector will be used to study of C-parity violation, invisible decay, and rare decay.

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Session Classification: Wednesday