Contribution ID: **671** Type: **Parallel session talk**

Experimental observation of polarization correlation of entangled photons from positronium atom using J-PET detector

Thursday 24 August 2023 08:30 (20 minutes)

Quantum entanglement is one of the fundamental correlations between particles that has not yet been confirmed with high-energy photons. Quantum electrodynamics (QED) predicts that annihilation photons produced by the decay of the singlet state of positronium (Ps) atoms are entangled in their polarization [1]. Since these photons have an energy of 511 keV, there is no polarizer to measure the polarization of these photons. However, the direction of the scattering photons when interacting with an electron via the Compton process depends strongly on the polarization of the photon [2]. Therefore, Compton scattering can be used as a polarization analyser. The polarization direction of the photon can be defined as the cross product of the momentum vector of the incident and scattered photon [3]. By measuring the polarization of annihilation photons originating from Ps decays, their polarization correlation can be determined. Measuring this correlation for the first time will answer the open question of studying quantum entanglement in high-energy photons [4]. It also has applications in PET imaging [5,6], where the quality of image reconstruction depends directly on the selection of pure annihilation photons.

J-PET is a multi-strip detector based on plastic scintillators that has the potential to measure such correlation in the whole phase space [7,8]. Photons interact with plastic mainly via Compton scattering, which makes J-PET particularly suitable for this type of study. In this presentation, the key-features of the J-PET detector, analysis scheme and the preliminary results of the study will be presented.

References:
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Collaboration / Activity

on behalf of J-PET

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Session Classification: T12 Detector R&D and Data Handling

Track Classification: Detector R&D and Data Handling