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First experimental demonstration of positronium lifetime imaging with ^{44}Sc using the J-PET Scanner

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On behalf of the J-PET collaboration

Abstract

Positronium lifetime imaging (PLI) [1], an extension of PET, provides insight into the submolecular properties of tissues by imaging the lifetime of the positronium atom [2]. Currently, the method is under rapid development as regards reconstruction [3,4] and detection systems [5,6]. The first studies with the J-PET scanner using ^{68}Ga have demonstrated the feasibility of this technique in human subjects [6]. However, the Ga^{68} isotope has limitations due to its low yield of de-excitation photons necessary for positronium lifetime estimation. In this context, ^{44}Sc emerges as a promising candidate for PLI [7], offering a clinically optimal half-life of 3.97 hours and a high de-excitation photon yield of 94.3% with an energy of 1157 keV. In this work, we report the results of the successful demonstration of PLI with ^{44}Sc using the Modular J-PET tomograph, featuring triggerless data acquisition that enables simultaneous multiphoton detection [8]. ^{44}Sc was produced at the Heavy Ion Laboratory in Warsaw and transported to Jagiellonian University in Kraków. A NEMA IQ phantom with six spheres was used. The three largest spheres were filled with ^{44}Sc, and the three smallest with ^{18}F, both diluted with water, having an initial activity concentration ratio of 1:3. Event selection was based on the simultaneous detection of two 511 keV photons and one de-excitation photon, enabling reconstruction of images of the mean positronium lifetime [2,6]. The measured mean o-Ps lifetime shows good agreement with previously reported values in water [9]. This study presents the first-ever demonstration of PLI with ^{44}Sc, marking a significant advancement and opening new possibilities for developing PLI for clinical applications.

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