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A scintillation dual-detector system featuring active Compton suppression

Dean Inwood
University of Wollongong

A SCINTILLATION DUAL-DETECTOR SYSTEM FEATURING ACTIVE COMPTON SUPPRESSION

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DEAN INWOOD, B. Med. Rad. Phys.

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I, Dean Inwood, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Master of Science, in the Department of Engineering Physics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Dean Inwood
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Abstract

This thesis focuses on the performance characterisation of two prototype scintillation dual-detector radiation monitors that feature active gamma-ray collimation and the suppression of events caused by Compton scattering. This system is currently under development at the Centre for Medical Radiation Physics (CMRP) for radio-guided surgery and lymphoscintigraphy procedures involving low and high-energy gamma ray emitting isotopes. The two CMRP custom-designed configurations of dual-scintillator CsI(Tl) crystals were optically coupled to custom designed Si photodetectors. One configuration, nicknamed "CD1," consists of an N^--type Si base with P^+-type circular inner and square outer regions, producing a p-n junction, while the other, "CD2," consists of an N^--type base with smaller P^+-type circular inner and outer regions. Both CD1- and CD2-type configurations were investigated for their current-voltage characteristics, noise, crosstalk levels and system energy resolution for various radioisotopes. Both types of device were then integrated into a Compton-event suppression system. The devices were found to require a reverse bias voltage of not more than -60V for the CD1 type device and –30V for the CD2 type. Noise prevents the resolving of low energy peaks below around 150 keV for the CD1 type and below 100 keV for the CD2 type and crosstalk levels were found to be <2% on both types of device. Energy resolution of the CD1-type inner detector was found to be approximately 13% for Cs-137's 662 keV peak and 8% for the CD2-type inner detector, while the resolution on the outer detector was found to be 21% for Cs-137's 662 keV peak for the CD1 type and 19% for the CD2 type. Both devices were successfully integrated into a Compton event suppression system and achieved significant levels of suppression of Compton events that would otherwise contribute to the Compton continuum. These results indicate that the dual-detector system will be satisfactory for radio-guided surgery and lymphoscintigraphy using both low and high-energy radioisotopes.