J. Nucl. Med. 33, p. 862 (1992)

DESIGN FOR A HIGH-RATE, HIGH RESOLUTION PET MODULE USING ROOM TEMPERATURE SILICON PHOTODIODES FOR CRYSTAL IDENTIFICATION. W.W. Moses, S.E. Derenzo, and T.F. Budinger. Research Medicine and Radiation Biophysics Division, Lawrence Berkeley Laboratory, University of California, Berkeley, CA.

We present a design for a new detector module for multi-layer PET that provides high maximum counting rates and high spatial resolution. The proposed module consists of an 8 by 8 array of 3 mm square by 30 mm deep BGO crystals coupled on one end to a single one inch square photomultiplier tube and on the opposite end to an 8 by 8 array of 3 mm square silicon photodiodes operated at room temperature. The photomultiplier tube provides an accurate timing pulse and energy discrimination for the 64 crystals in the module, while the silicon photodiodes identify the crystal of interaction. This design takes advantage of the low cost and size of solid-state photodetectors as well as the good timing and signal-to-noise ratio of photomultiplier tubes.

The proposed module is a factor of two to four smaller than existing block detector designs, which increases the maximum coincident event rate by the same factor. This increased rate capability is valuable in cardiac and 3-D imaging situations. The individual coupling of scintillator crystals to photodetectors removes the mis-positioning error caused by statistical fluctuations in the light-sharing, which improves the spatial resolution. We expect this design to yield 3.3 mm in-plane and 2.6 mm axial resolution in a cardiac PET camera, and 2.6 mm in-plane and 2.0 mm axial resolution in a neurological PET camera. The design can be optimized for different cost or performance goals by varying the size of the photomultiplier tube and the BGO crystals.

A prototype assembly consisting of a single 6 x 6 x 30 mm BGO crystal coupled to a photomultiplier tube and a 10 x 10 mm photodiode was constructed and operated at +10˚ C. A 511 keV photopeak with 62% full width at half maximum (FWHM) is clearly seen above background. Reducing the photodiode area to the proposed 3 x 3 mm will permit room temperature (+25˚ C) operation with a 511 keV photopeak FWHM of 50%, which is sufficient to identify the crystal of interaction.