Symposium

Progress in Positron Computed Tomography Devices

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Positron emission computed tomography has recently made remarkable progress for cyclotron nuclear medicine. Many devices for positron tomography have been developed and are now in clinical use. Performances of these devices are being improved one after another so as to provide high quality diagnostic images. For high quality images the devices are desired to be of high sensitivity, high resolution and rapid imaging capability. Sensitivity is mainly determined by geometric efficiency and detector efficiency. Resolution depends strongly upon crystal dimensions and geometric sampling characteristics. High geometric efficiency is provided with circular ring detector systems. Use of bismuth germanate crystals is at present the most suitable for detection of positron annihilation photons with high efficiency and resolution, although other materials such as CsF are considered for fast dynamic studies. One of serious problems with circular ring systems is the geometric sampling characteristics. Early developed stationary ring systems which have an equally spaced detector array on a circle can never provide sufficient sampling characteristics to recover coincidence detector resolution. As an inevitable consequence, they need some detector ring motions such as rotation and wobble. One solution to attain sufficient sampling characteristics with a circular ring system is to rotate a ring array of unequally spaced detectors. The detector array has to be searched under restrictions of design parameters taking the system performances into account. Searching of the detector array, which we call "Positology", is quite significant since the detector array has an important effect upon its sampling characteristics. A practical and feasible method to seek the detector array is an iterative search by a computer. Rotary positron tomographs designed so provide excellent sampling characteristics with high detector redundancy. This excellence has been demonstrated with a device, POSITOLOGICA, developed at National Institute of Radiological Sciences, Chiba, 1979.

One of prospective positron tomography devices in near future will be a circular ring detector system composed of crystals whose width is smaller than that used so far. The adoption of the small crystal width, however, will cause loss in efficiency due to increases of septal gaps between the crystals and of radiation spillage in each crystal. In addition, such a detector system will be afflicted with a constrained optimisation of optical coupling between the crystals and photomultiplier tubes, as long as the commercially available photomultiplier tubes are used. Development of new photomultiplier tubes, therefore, will be required to fit them to the small crystal width.

In order to make effective coupling with photomultiplier tubes available at present, a concept of quad crystal detectors will be introduced to the detector system. The quad crystal detectors

have been successfully developed using bismuth germanate crystals, and will be used in a system under construction for whole body positron tomography with multiple slice geometry. The detectors allow use of the crystals whose width is half the diameter of photomultiplier tubes used, providing optically effective coupling between them. Instrinsic resolution of the prospective detector system will be discussed taking account of effects of radiation spillage, shielding due to the neighbouring crystals and septa between the crystals, together with other important parameters in physical and engineering aspects.