Time-of-Flight

See references (21-28) for descriptions of positron tomographs using time-of-flight information for improved randoms rejection, high maximum data rates, and reduced statistical noise.

Avalanche Photodiode- BGO detectors

One approach for the eventual elimination of the glass PMT is the use of "solid state PMTs" in which electrons are multiplied in high field regions within the photodiode material.[96–101] At the present time, these devices are considerably more expensive than glass PMTs and have poorer timing resolution.

Lightpipes and external PMTS

For several years, an ambitious and novel high resolution positron tomograph design using plastic scintillators and a coded optical fiber readout has been investigated at Texas A&M University. A full tomograph would have 8 detector layers each consisting of 16 concentric rings of 1024 scintillators per ring (a total of 131,072 independent scintillators), and 356,352 optical fibers would couple the scintillators to 576 PMTs.[102]

Combined Phototube- solid state readout

This approach combines the excellent timing resolution of the PMT with the small size of solid state photodetectors (Figure 3). A group of crystals is coupled to a relatively large photomultiplier tube which determines the timing for the group. The solid-state photodetectors are coupled individually to each crystal to determine the identity of the scintillating crystal. Candidates for the photodetector include HgI_2,[103–106] silicon photodiodes,[45,107–109] GaAs photodiodes,[110] silicon avalanche photodiodes,[97–100] and small low-gain PMTs.[93] This method is good for very small crystals, since the noise of solid state photodetectors decreases with decreasing area, and the signal is nearly independent of crystal size. In addition, it permits the rejection of multiple-crystal interactions that degrade spatial resolution.

The feasibility of this concept has been demonstrated using a 3 mm wide BGO crystal in coincidence with two 3 mm wide BGO crystals coupled to a common 14 mm PMT and individually coupled to low-noise silicon photodiodes. The signal to noise ratio was adequate for the identification of the individual crystals on an event-by-event basis and the measured detector pair resolution was 2.0 mm fwhm.[45,108]