13.4.5 Definition and how to deal with randoms and multiples

Simultaneous annihilations (or pairs of photons generated by the source) can cause erroneous coincidence detection. This document makes a distinction between what are generally referred to in literature as Randoms and Multiple. Provisions are given on how to eliminate or account for them.

13.4.5.1 Randoms

Random coincidences occur when two unrelated photons hit two detectors (see Figure 13-8) within the time window used to detect true coincidences.

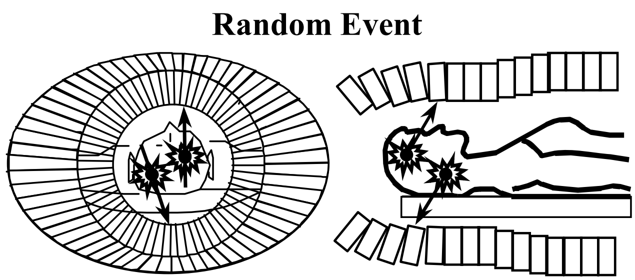

Figure 13-8. Randoms.

13.4.5.2 Multiples

Multiple coincidences occur when more than two photons hit more than two detectors (see Figure 13-9) within the time window used to detect true coincidences.

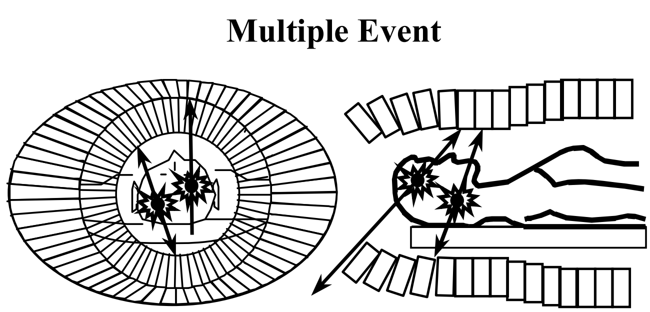

Figure 13-9. Multiples.

13.4.5.3 How to identify Randoms and Multiples, correct, and/or reject them

Random and Multiple rates are proportional to the rate of hits (or singles) to each detector and to the time coincidence window with the following relation:

(Random + Multiple) = $Rate_1$ x $Rate_2$ x $2\Delta t$

Where $Rate_1$ is the rate of a single at detector 1, $Rate_2$ is the rate of singles at detector 2, and Δt is the time coincidence window. They are reduced by reducing the rate of the singles at the detector and the time window coincidence. Both parameters are reduced by the proposed design with the 3D-Flow because

a) the increased FOV of the detector reduces the percentage of singles (see Section 3, and Figure 3-2) with respect to the total radiation activity (and an increased FOV requires also a lower radiation dose to be delivered to the patient); and

b) the time window coincidence is reduced by the accurate time measurement, which is improved by the CFD, TDC, the front-end operations in the FPGA, and the DSP functionality of the 3D-Flow, which can improve accuracy of the time stamp assigned by the TDC with the digital signal analysis of the PMT pulse received from the shaper amplifier. This increased efficiency made merely with the improvement in the electronics. A further improvement in the time resolution can be effected by the use of faster crystals with shorter decay time; however, this strategy will entail additional cost.

13.4.5.4 Compton scatter: how to detect these events, and/or correct and/or reject them.

Compton scattering is the collision between a photons and a loosely bound outer shell orbital electron of an atom. Because the energy of the incident photon is much greater than the binding energy of the electron to the atom, the interaction looks like a collision between the photon and a free electron. The incident photon in a Compton scattering deflect through a scattering angle θ. Part of the energy of the incident photon is transferred to the electron and the energy loss is related to the scattering angle of the scattered photon at lower energy. It is a photon-electron interaction and the energy transferred does not depend on the density, atomic number or any property of the absorbing material.