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:

$$(\text{Random} + \text{Multiple}) = \text{Rate}_1 \times \text{Rate}_2 \times 2\Delta t$$

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.

Events of this type have one of the pair of photons at 511-keV that "Compton scatters" in the patient but still interacts in the detector ring. (Some others Compton scatter in the detector ring.) The result is a coincidence event because it satisfies the coincidence time window; however, the line connecting the detectors which sensed the hits is invalid.

Compton scattered Event

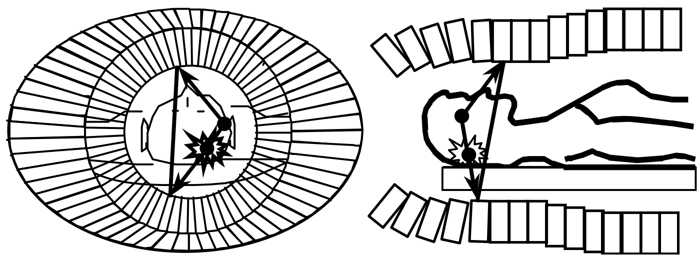

Figure 13-10. Compton scatter

Better energy resolution improves Compton scatter correction and rejection. The 3D-Flow system has the capability of improving the energy resolution by:

a) handling the detector as a single large array of signals received from PMTs or other transducers or a combination of them, rather than by defining boundaries in the detector, as is the case in current detectors,

b) having the capability of identifying, anywhere in the detector array, the head of the cluster (the sensor absorbing the highest scintillating light of the incident photon compared to its neighbors; see local maxima detection in Section 13.4.11.2) and then reconstructing the energy of the incident photon by adding the energy value of its neighbors (3x3, 4x4, or 5x5, etc., according to the size of the array). This calculation corrects for events which scatter in the detector

c) applying the attenuation correction when the photon is identified in the stack of the 3D-Flow. This attenuation correction is for the SPECT operation mode, based on attenuation maps obtained with septa-in, and the calibrating parameters are obtained using the transmission source rotating around the patient's body. A more accurate attenuation correction can be obtained when the device is