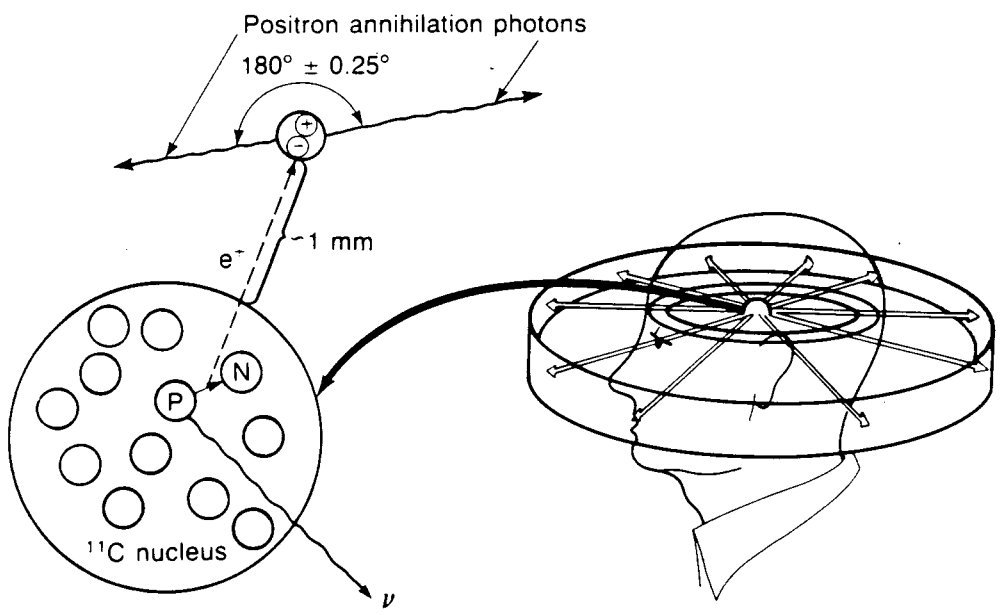

Figure 1: A positron emitted by nuclear decay stops in tissue and annihilates with a nearby electron, producing two 511 keV annihilation photons that fly off in nearly opposite directions.

3) If the positron were able to loose all of its kinetic energy before annihilation, the two 511 keV annihilation photons would be emitted in exactly opposite directions. However, the positron has a residual energy of typically 10 eV, and this causes the angle between the photon pair to have a Gaussian distribution with a full-width at half-maximum (FWHM) of 0.50° (5).

4) A 511 keV photon will travel an average of 10 cm in water before interacting by Compton scattering. This process reduces its energy and randomly changes its direction, effectively loosing all image information. Since the human head or chest is approximately two interaction lengths thick, the probability that both annihilation photons leave the body unscattered is only about 20%. This represents a significant loss of events and requires large correction factors. Also, a small but significant fraction of the annihilation photons scatter "in the plane" of the tomograph and are detected as prompt (non-random) coincidences. These result in a heterogeneous background that extends beyond the subject over the entire imaging field.

5) The annihilation photons can interact in the scintillator in two ways– (i) by photoelectric effect, whereby the entire 511 keV is given to a recoil electron, or (ii) by Compton scattering, where only a portion of the full energy is given to a recoil electron and the photon is reduced in energy and scattered into a new (random) angle. For BGO the probability of a photoelectric event is about 50% for the first interaction. For BaF_2 this probability is about