Proposal of the Fluoroscopes Using Gamma Ray Generated from Electron Positron Pair Annihilation with Low Exposed Dose

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Introduction

X-ray Computed Tomography(CT) has high exposed dose. The exposed dose in one X-ray CT is approximately 20 μ Sv. There are two causes for the high exposed dose. One is that the X-ray transmittance to the living body is low. Suppose that the human body is a cylinder with a diameter of 30 cm. The transmittance of X-rays to the cylinder is approximately 0.5%. The other is noise due to Compton scattering in the organism. Let the signal-to-noise ratio be 1:k.we need $(1+k)^2$ signals in order to obtain the same result as in the state without noise. Therefore, the exposure dose is high. The CT we propose uses gamma rays generated from electron positron pair annihilation. Gamma ray transmittance in the cylinder is as high as 5.6%. Also, noise can be reduced to 0 by the method described latter.

Development of transmittance

Conceptual diagram of gamma ray CT is as shown in Fig.1. ^{68}Ge/^{68}Ga produces positrons. The positrons irradiate to inorganic scintillator, and annihilate. The point where the positron annihilate is measured with an error of 0.2 mm. At that time, two gamma rays are generated. One gamma ray is irradiated opposite to the living body and strikes the detector. The point of the gamma ray is measured with a position resolution of 0.2 mm. When connecting the position of annihilation and the detection position of gamma ray with a straight line, the position of the other gamma ray can be predicted. The transmittance of gamma rays can be measured by measuring the presence or the absence of gamma rays at that position. By performing this measurement so as to surround the living body, it is possible to see the inside of living body as an image. At this point it is expected that the exposed dose will become 1/10 compared to X-ray CT.

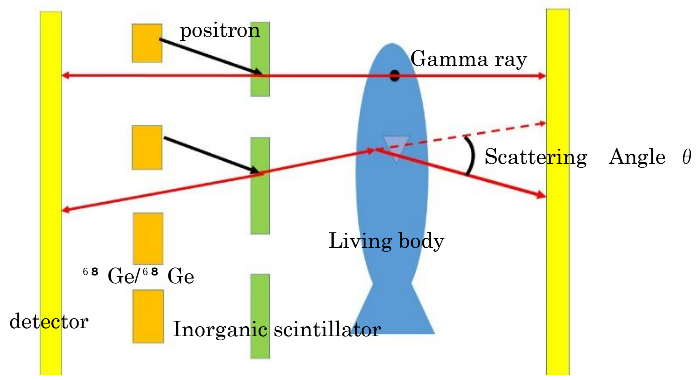

Fig1 Conceptual diagram of gamma ray CT

Events of Compton scattering

The scattering point distribution is directly measured by measurement of the Compton scattering event. Gamma rays are irradiated with energy at 511 keV. The relationship between scattering angle and energy after scattering can be easily obtained. As can be seen from Fig2, the energy largely depending on the scattering angle of the gamma rays. Therefore the scattering angle can be measured if energy is measured. The point where gamma rays strike is measured by the detector. The scattering point is measured from the point of the gamma ray and the scattering angle, if not scattered. This almost eliminates noise due to Compton scattering. We are developing a detector with 511 keV energy resolution of 4%. If we use it, the error in the direction of irradiation is 6mm for gamma rays.

This measurement method measures material distribution directly from Compton scattering. Therefore, the number of events is 1/100 compared to the usual CT examination method which calculates the three-dimensional substance distribution from the two-dimensional perspective image.

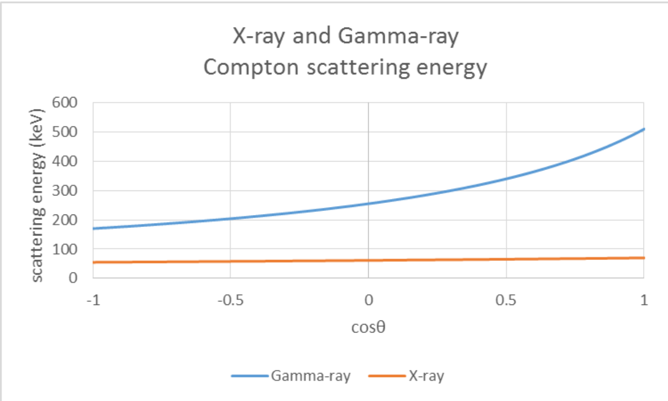

Fig2　Compton scattering energy to show difference in energy of X-ray and Gamma ray.