Monochromatic X-ray CT Using Fluorescent X-rays Generated by Synchrotron Radiation

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In medical imagings by using synchrotron radiation, such as K-edge subtraction angiography and monochromatic X-ray CT, it is necessary to use high intensity monochromatic X-rays of different energies. There are several ways to produce monochromatic X-rays. The most popular one is based on crystal diffraction, in which the energy spread is very narrow and the energy can be continuously changed. In this method, however, it is difficult to obtain large area X-ray beams enough to a whole body CT.

The fluorescent X-rays generated by irradiating a metal target materials with white X-rays offer a large beam size due to its divergent characteristics[1]. Thus we planned to develop quantitative X-ray CT imaging system using fluorescent X-rays.

Several kinds of fluorescent X-rays ranging generally from about 20 to 70 keV were generated by irradiating different target materials with white X-rays from the 6.5 GeV AR-ring in KEK as shown in Fig.1. The intensities of the fluorescent X-rays were 6.2×10^5 to 3.0×10^5 photons / $mm^2 \cdot sec \cdot mA$ at 30cm from the focal spot on the target. The purity of the K_α X-rays were improved to more than 95% by using K_β attenuation filters.

Cylindrical phantoms filled with contrast media with different iodine concentrations were used as quantitative imaging objects. 120 projections covering 360 degrees were obtained by rotating the object by using a 64 channel CdTe array detector ($2 \times 2mm^2 \times 0.5mm$ /channel) operated in photon counting mode.

Monochromatic X-ray CT images of cylindrical phantoms filled with iodine of various concentrations ranging from 0.1 to 80mg/ml have been obtained by using filtered back-projection[2]. The experimental Hounsfield unit calculated from the central ROI of each image and theoretical Hounsfield unit for low concentration region are plotted in Fig.2. The magnitude of the experimental Hounsfield unit were about 30% less than the theoretical values which are calculated from the attenuation coefficients. Detected

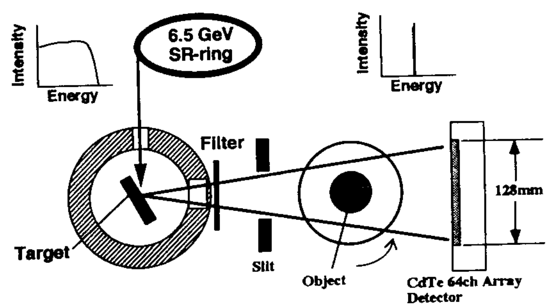

Fig.1 Schematic diagram of monochromatic X-ray CT using fluorescent X-ray

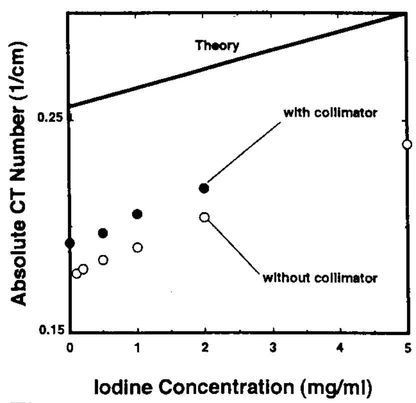

Fig.2 The relation between measured and calculated CT numbers

photon numbers attennuated by different Aluminum plate thickness suggested that 7.5% scattering X-ray component might contaminate the recorded value. However, the linear relationship between the thickness of Aluminum plate and the photon number was fairly good. Quantitative CT images without beam hardening effect may be, therefore, obtained using Hounsfield unit normalization.

The fluorescent X-ray source usingthe synchrotron radiation will be useful for quantitative element selective imaging.

References

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