Third Generation Computed Tomography with Energy Information of X-rays using a CdTe Flat Panel Detector

transXend

I.Kanno, R. Imamura, Y. Minami, M. Ohtaka, M. Hashimoto, K. Ara, H. Onabe
Kyoto Univ., JAEA, Raytech Corp.

Background

X-ray CT: X-ray absorption ⇨ 2-3 dimensional images

Effective in early finding of cancers

Problems
- ◆High dose exposure (some 10~1000 times higher than chest radiography)
- ◆Side effect of iodine contrast agent
- ◆Beam hardening effect

Our Previous Study

- ◆Usage of (La) filtered X-rays

Cutting off extra X rays ⇨ Dose reduction of 70%

Energy spectra measurements by a CdZnTe detector ⇨ Energy subtraction CT

- ◆Twofold better iodine contrast than current meas.
- ◆Beam hardening effect free

X-ray CT with Energy Information

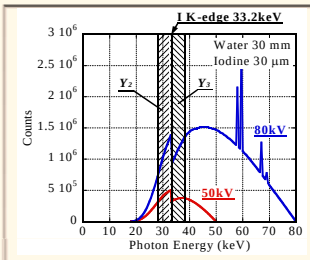

Fig. 1 Energy spectra of X-rays at tube voltages of 50 and 80 kV.

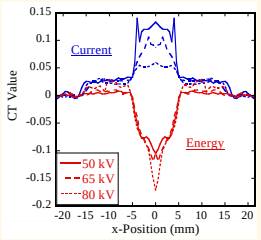

Fig. 2 Energy-subtraction-based CT values obtained by a CZT detector.

◆Energy range E_n events Y_i

$$Y_i = \Psi_A(E_i)\cdot\exp\{-\overline{\mu_I}(E_i)\cdot t_I\}\exp\{-\overline{\mu_W}(E_i)\cdot t_W\}$$

Ψ_A: X-ray events before entering a subject

μ_I, μ_W: mass attenuation coefficients of iodine and water

t_I, t_W: thicknesses of iodine and water

◆Free from the beam hardening effecct
◆Improvement in iodine contrast

However, very long measurement time ⇨ transXend Detector

transXend Detector

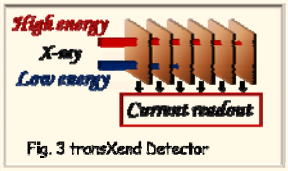

Fig. 3 transXend Detector

$$\begin{pmatrix} I_1 \\ I_2 \\ \vdots \\ I_6 \end{pmatrix} = \begin{pmatrix} R_{1,1} & R_{1,2} & \cdots & R_{1,6} \\ R_{2,1} & R_{2,2} & & \vdots \\ \vdots & & \ddots & \\ R_{6,1} & \cdots & & R_{6,6} \end{pmatrix} \begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_6 \end{pmatrix}$$

Table 1 Energy range (keV).

E_1	20~27	E_4	40~60
E_2	27~33	E_5	60~80
E_3	33~40	E_6	80~120

I_n : Current
$R_{n,I}$: Response function
Y_i : X ray energy distribution
n :Channel
E_i :Energy range

CT Values Obtained by transXend Detector

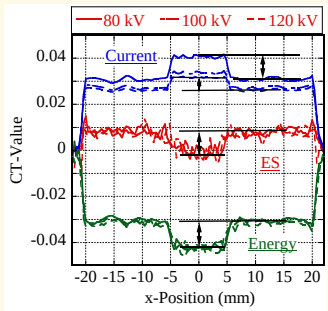

Fig. 4 CT values obtained by the first generation CT. ES : Y_2/Y_3, Energy : Y_3, Current: conventional.

Purpose of This Study

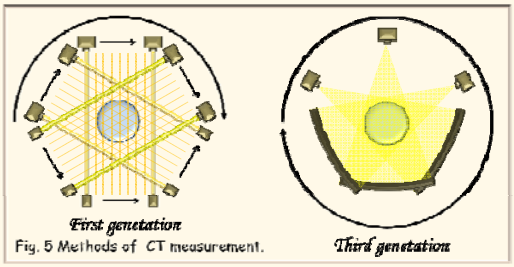

Fig. 5 Methods of CT measurement.

1st generation (pencil beam) CT ⇨ 3rd generation (fan beam) CT

Measurement time reduction & Energy information

CdTe flat panel transXend Detector

CT Measurements

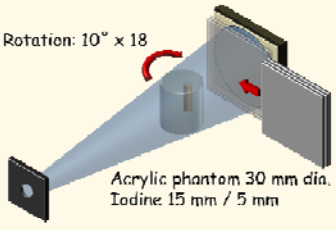

Fig. 6 Experimental setup.

With changing the number of Al absorbers, energy information is obtained.

Fluctuation in measurement values is due to the response difference of each pixel

Smoothing by the weighting average

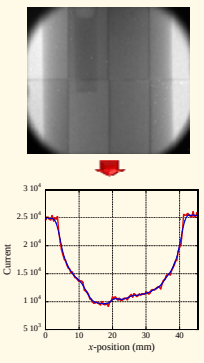

Fig. 7 Measured image and current values.

Results

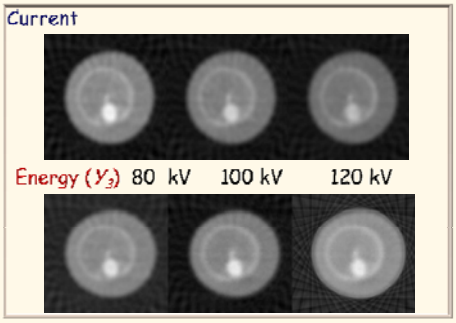

Fig. 8 CT images by 80, 100, 120 kV tube voltages.

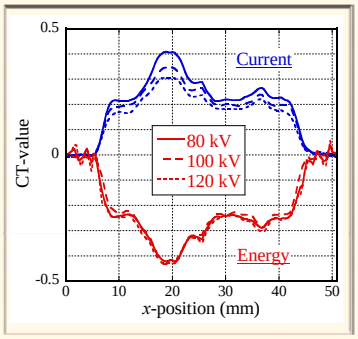

Fig. 9 CT values obtained by current and energy CT.

CdTe Flat Panel Detector

FPD4X2, Acrorad, Japan
Active area 51.5 x 46.5 mm²
512 x 464 pixels
(1 pixel:0.1 x 0.1 x 1 mm³)

Absorber Changer

Movie is on PC

Summary

CdTe-FPD + Al absorbers ⇩ Quasi-transXend detector

CT images with energy information of X-rays
Short measurement time
Iodine contrast ~1.7 times higher than current CT

Future Plan

- ◆Cooling CdTe-FPD
- ◆Different absorber materials

Thanks to

Suzuken Memorial Foundation for supporting this study.