Target Size Dependence of Spatial Resolution in Heavy Ion CT

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ABSTRACT

In order to achieve the radiotherapy more precisely using highly energetic heavy charged particles, it is important to know the distribution of the electron density in a human body, which is highly related to the range of charged particles. We can directly obtain the 2-D distribution of the electron density in a sample from a heavy ion CT image. For this purpose, we have developed a heavy ion CT system using a broad beam. The performance, especially the position resolution, of this system is estimated in this work. All experiments were carried out using the heavy ion beam from the HIMAC. We have obtained the projection data of polyethylene samples with various sizes using He 150 MeV/u, C 290 MeV/u and Ne 400 MeV/u beams. The used targets are the cylinders of 40, 60 and 80 mm in diameter, each of them has a hole of 10 mm in diameter at the center of it. The dependence of the spatial resolution on the target size and the kinds of beams will be discussed.

Keywords: heavy ion radiotherapy, heavy ion CT, electron density, position resolution

1. INTRODUCTION

In a current treatment planning of the heavy ion radiotherapy, the CT number from an X-ray CT image is converted into the corresponding electron density. Although some conversion methods have been proposed, a slight disagreement exists among them. The direct measurement of the electron density of real tissue equivalent samples using a heavy ion CT (HICT) system will make it possible to adjust the relationship between the CT number and the electron density. We have already established a heavy ion CT using a pencil beam scanning method [1). As an extension of this method, a detector system for a broad beam was developed to decrease the total amount of dose and to shorten the measuring time. The final purpose of this research is to estimate the performance of the HICT system with a broad beam and to put it to a practical use.

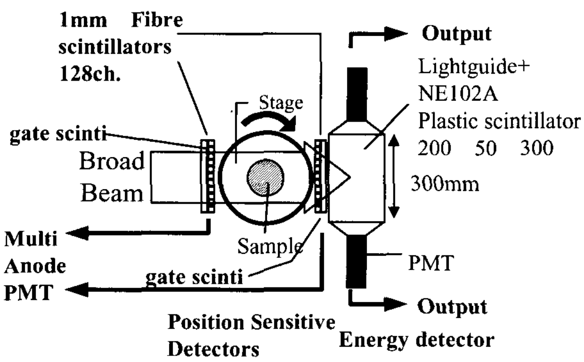


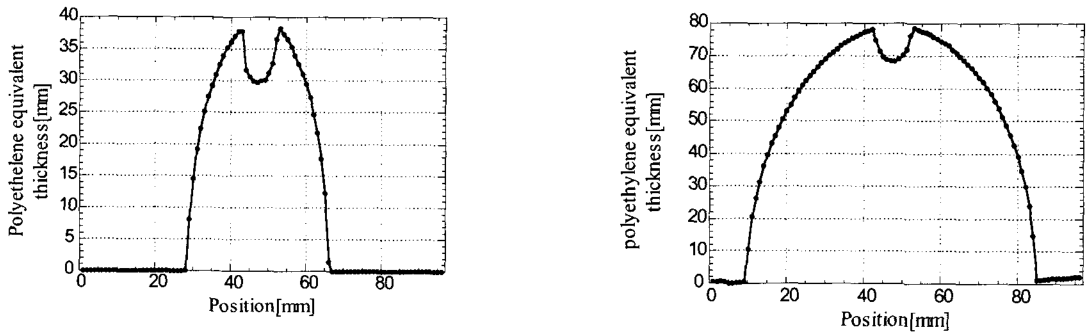
Fig.1 Experimental setup of detector system

2. EXPERIMENTAL PROCEDURE

All experiments were carried out using ^{12}C beam of 290 MeV/u, ^{20}Ne of 400 MeV/u and ^{4}He of 150 MeV/u at the BIO course of the HIMAC. Figure 1 shows the experimental arrangement to obtain a CT image by using a broad beam. Two position sensitive detectors are placed in front of and behind a sample to monitor the position of heavy ions and the residual energy is measured in coincidence with two gate scintillators. Although the residual energy information on each position of the projection data is expressed with the channel number of ADC, it is required to convert it into the equivalent thickness of a calibration substance to perform a CT reconstruction. Then, the projection data are measured by changing the thickness of a calibration substance (polyethylene), and the energy calibration between a channel number and an equivalent thickness of a calibration substance is performed. The CT image reconstructed from the projection data expressed as the equivalent thickness of a calibration substance shows the electron density ratio of the sample to the calibration substance.

3. RESULTS

The obtained data of the cylinders of 40 and 80 mm in diameter, each of them has a hole of 10 mm in diameter at the center of it, using a ^{12}C beam of 290 MeV/u are shown as examples.



a) 40 mm in diameter (b) 80 mm in diameter

Fig. 2. One-dimensional projection data. The horizontal axis and the vertical axis represent the position and the polyethylene equivalent thickness [mm], respectively.

Figure 2-(a) shows the projection data of 40 mm in diameter and Fig. 2-(b) shows those of 80 mm in diameter. The reconstructed images from the projection data are shown in Fig. 3-(a) and Fig. 3-(b). In order to discuss the difference in images quantitatively, the cross sectional view on the center axis of the sample is shown in Fig. 4.

(a) 40 mm in diameter (b) 80 mm in diameter

Fig. 3 Reconstructed Images.

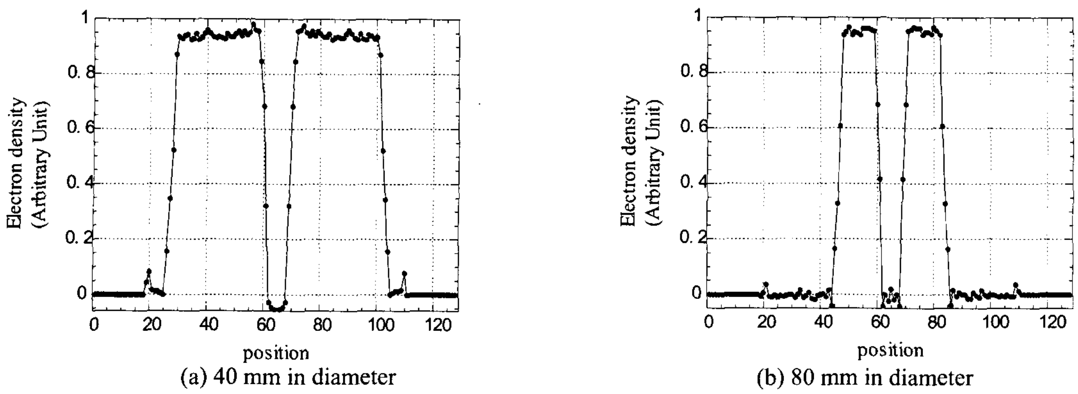


Fig.4. Electron density distribution on the center axis of Fig.3. The horizontal axis represents the position and the vertical axis represents the electron density respectively

The spatial resolution of Fig. 4-(b) was somewhat worse than Fig. 4- (a). The discussion of the dependence of the spatial resolution on the target size and the kinds of beams is now in progress.

REFERENCE

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