In Vivo Proton Radiography on the PSI Gantry ◊

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1. Summary

In the fall of 1999 the first in vivo proton radiography on the PSI gantry was performed by scanning a dog patient. The measured proton range information is used to check the accuracy of CT-based range calculations used in the treatment planning with protons.

2. Introduction

Most of the dog patients so far treated with protons on the PSI gantry had nasal tumors. Due to the presence of air cavities as well as brain and bone tissue in this region its density is very heterogeneous. These conditions can result in uncertainties in range calculations and hence in an inaccurate dose distribution.

By measuring the residual range of single protons after traversing the patient with the radiography system installed on the PSI gantry [1,2] we obtain range information that can be used to verify the range predictions of the treatment-planning procedure installed for proton therapy.

Our proton radiography system performed stably throughout the beam period of 1999. Its second position-sensitive detector was successfully redesigned, tested and mounted in the gantry.

Since the system can now be put into operation within a few minutes, it was possible to take in vivo radiographic data of a dogs head.

3. Method and Results

We want to compare the distribution of water equivalent thickness(WET) used in treatment planning, obtained from a CT scan to those obtained by proton radiography for a given patient position. Both data sets were taken while the dog patient was anaesthesised for radiotherapy on the PSI gantry. Additional radiographic data was taken on a water phantom for an offline calibration of the system in units of WET.

Fig. 1 shows two radiographic transmission images.

The one on the right is a digitally reconstructed radiography calculated from the CT data. This image is produced by converting the CT Hounsfield values into proton stopping power with the calibration curve used for therapy planning in converting CT units into WET. To obtain a two-dimensional map of range information, the volume data was integrated in the direction corresponding to the direction of the proton-radiography beam. The resulting image is a map of the reconstructed WET values of the scanned object.

The image on the left is obtained from the proton data. Since for each detected proton, entry and exit coordinates as well as its residual range are measured, one can determine the mean residual range for all protons in each detector pixel and from it the WET value of the tissue traversed.

A quantitative analysis of the comparison between the two images is currently in progress.

Fig. 1: Radiographic images of the head of a dog: proton data (left) and a reconstruction from CT data (right)

4. Outlook

By further optimising our data analysis and data taking we hope to gain the information and experience needed for the ultimate step to human patients. A major effort will be the implementation of a dedicated monitoring system to ensure the safety of the patients. We also hope to learn to use proton radiography as a tool for verifying the patients positioning as proposed in [3].

References

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◊ supported by the Bavarian Minister for Environmental Affairs