Proton Radiography on the PSI Gantry : A Status Report ◇

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Introduction

A proton-radiography system was developed in collaboration with the department of radiation medicine at the Paul-Scherrer-Institute, Switzerland [1]. By measuring the residual range of protons transmitted through the patient in coincidence with the spatial coordinates, proton radiographies of high density-resolution are produced. Reports on performance tests of the system and on first results can be found in [1–3].

In 1998 efforts were made to optimize the detector and electronic performance as well as to prepare the integration of the radiography system into the patient-treatment environment.

Status of the project

In 1998 the radiography system was mounted on the gantry and tested in the working position. The system showed stable performance, and reproducible results were obtained.

The detectors are mounted in two boxes, which can be moved into the beam position by remote control, one in front of the patient and one behind. The two-dimensional scans are performed by sweeping the proton-pencil beam (proton rate of 1 MHz) in one direction across the detector width and by moving the patient table in the orthogonal direction. From the scan data two-dimensional maps of mean range and range uncertainty can be obtained and displayed within five minutes after starting the scanning process. The range information is calculated from the proton-range distribution for each detector pixel. Therefore the density resolution of proton radiography and thus the image quality strongly depends on the number N of 'good' events per detector pixel ($1/\sqrt{N}$) as well as on the uniformity of these values for all pixels. Ideally only events containing a complete set of coordinate and range information are accepted by the data aquisition. By optimizing the event trigger and the settings of the electronic units the rate of ambiguous events could be reduced and the statistical yield per pixel was improved considerably.

We reported on non-uniform pixel sizes due to misalignment of the scintillating fiber array as delivered by the manufacturer [1,2]. One of the position-sensitive detectors is therefore beeing rebuilt with a new set of fibers with less coating material. A special mounting was designed to ensure a precise alignment of the fibers. In this way we expect to improve not only the uniformity of the pixel sizes and thus the image quality but also the overall efficiency of the system resulting in a shorter exposure time and a lower dose delivered to the patient.

On a water phantom we measured the residual range of protons in a stack of scintillating plates as a function of water depth. From this data a calibration curve in units of water-equivalent depth can be obtained.

Radiographic images and CT-scans of the Alderson phantom were taken for different incident beam directions (fig. 1). The range information calculated from the data samples can be compared to the results of the treatment planning algorithms to check the precision of the range predictions in the phantom [4].

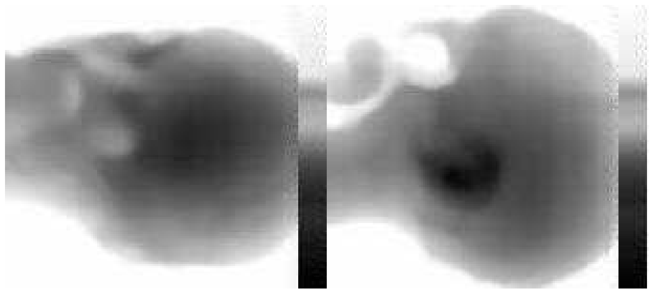

Fig. 1: Radiographic images : Residual range of protons transmitted through the Alderson phantom (head) for two different incident beam directions(Greyscale).

Outlook

A preliminary range calibration of the radiography system will be performed using data taken on the water phantom.

An additional safety concept has to be designed and approved in order to proceed with the integration of the radiography system into the patient treatment environment.

Finally radiographic images of dogs with nasal tumors that are treated at PSI will be taken and compared to the range predictions given by the treatment-planning algorithms.

References

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[2] P. Pemler *et al.*, Jahresbericht 1996
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◇ Supported by the Bavarian Minister for Environmental Affairs