

Range Measurements Using Visible Scintillation Light for Proton Therapy

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Abstract—Proton beam therapy has certain advantages over that with the photon: a well-defined range, relatively little scattering, and high-energy deposition in the Bragg peak area. The depth dose distribution of proton beams shows a prominent Bragg peak at the end of the range, beyond which the dose rapidly falls to zero. Therefore, proton therapy makes possible to concentrate dose on tumor without increasing exposure on normal tissue. As a tool of daily treatment, an easy-to-use reliable range measurements method is required. We examined a method using visible scintillation light. We recorded visible scintillation light generated by proton irradiation on a block of plastic scintillator, and analyzed the length, shapes and brightness distribution to obtain the range, the magnitude of multiple coulomb scattering and the depth dose distribution. The precision of the range measurement is 0.7 mm. The relation between proton range in plastic scintillator and that in water shows good linearity, because physical property of plastic scintillator and that of water have some similarity. Estimation of the depth dose distribution by measuring the brightness distribution was possible with a digital video camera. This measurement method is proved to be an easy-to-handle way as a tool for QA/QC of proton therapy. The depth dose measurements within this accuracy provide critical data for testing the treatment-planning program for proton therapy using the GEANT4 code.

I. INTRODUCTION

Proton beam therapy has certain advantages over that with the photon: a well-defined range, relatively little scattering, and high-energy deposition in the Bragg peak area. The depth dose distribution of proton beams shows a prominent Bragg peak at the end of the range, beyond which the dose rapidly falls to zero. Therefore, proton therapy makes possible to concentrate dose on tumor without increasing exposure on normal tissue. On the other hand, protons are lost

according to nuclear interactions with atomic nuclei. To improve the accuracy of a radiation treatment planning, it is necessarily to estimate the proton attenuation due to the nuclear reactions. The purpose of this research is to measure the proton range using visible light from plastic scintillator. This research was performed at the national cancer center hospital east, Japan.

II. MATERIALS AND METHODS

In this research, we measured the range and depth dose distribution using visible scintillation light [1].

We recorded visible scintillation light generated by proton irradiation on a block of plastic scintillator (Digital Video Camera: *Canon DM-FV30*). The plastic scintillator is shown in Fig. 1 [2]. And we analyzed the length, shapes and brightness distributions of visible scintillation light to obtain the range and the depth dose distribution. We analyzed images by using automatic analysis tool developed by us.

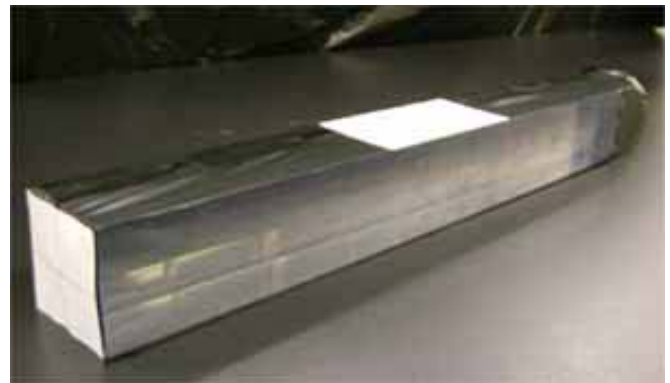


Fig. 1. Plastic scintillator block (*BICRON BC-400*, 50*50*400 mm)

III. RESULTS

We succeeded in measuring the range and depth brightness distribution of the proton as shown in Figs. 2(a) and (b), respectively. The precision of the proton range measurement is determined to be 0.7 mm. The relation between proton range in plastic scintillator and degrader thickness that reduce the proton beam energy shows a good linearity (Fig. 3). We could measure variation in the range during a typical irradiation-time

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interval for therapy. Range varied from 310.3 mm to 311.0 mm in 60 sec (Fig. 4).

Additionally we could observe a Bragg peak of depth brightness distribution. However, compared with the depth dose distribution measured with the ionization chamber in water phantom, the height of Bragg Peak was 20% lower [3]. We conform the end of brightness distribution to the end of dose distribution as shown in Fig. 5.

This simple and easy-to-handle method can be used to confirm the proton range prior to the irradiation as a tool for QA/QC of proton radiation therapy.



Fig. 2(a) Measured image (Energy: 235 MeV, degrader thickness: 0 mm).

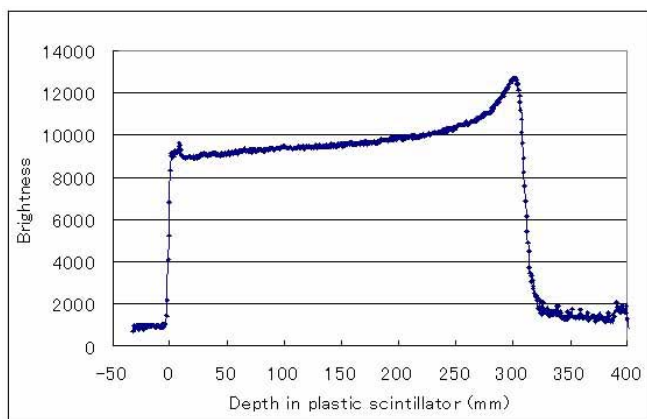


Fig. 2(b) Depth dose distribution (Energy: 235 MeV, degrader thickness: 0 mm).

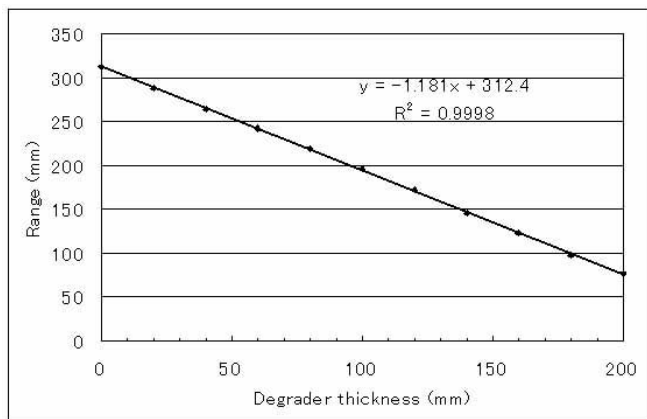


Fig. 3. Relation between proton range in plastic scintillator and degrader thickness.

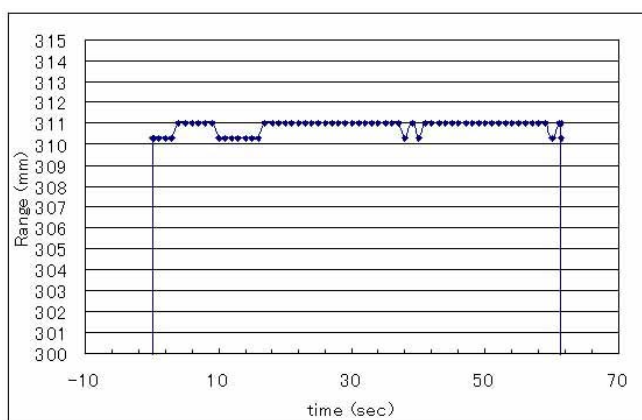


Fig. 4. Time dependent variation of the range. The range varied from 310.3 mm to 311.0 mm in 60 sec.

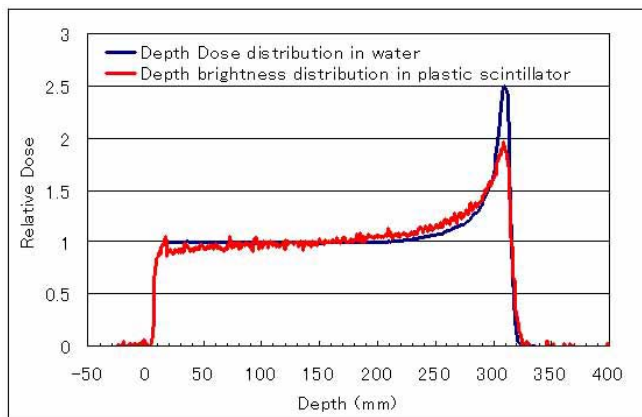


Fig. 5. Comparison between the depth dose distribution in water and the depth brightness distribution in plastic scintillator.

IV. CONCLUSION

We successfully measured the proton range by recording the visible scintillation light from a block of scintillator with a commercially available video camera. The Bragg peak can be observed. A good linearity in the range and energy relation indicates that this method can be applied to confirm the range of the therapeutic proton beam during daily treatment. We conclude that this research is useful for the improvement of the accuracy of proton therapy.

V. REFERENCES

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