Improvement of depth dose meter using scintillation fiber blocks for medical use

S.Ozeki, K.Tanisada[(1)],M.Yuasa[(1)], S.Fukushima[(2)],Y.Kawagoe[(3)],H.Hasegawa[(3)], Ta.Inoue[(4)], To.Inoue[(4)],H.Nishizawa[(5)],E.Teratani[(5)],M.Seno[(5)], K.Ikegami[(5)] and K.Hatanaka[(6)]

Genome Information Research Center, Osaka University
(1)School of Allied Health Science, Osaka University
(2)Depatment of Radiology, Medical School, Nihon University
(3)Osaka University Medical Hospital
(4)Department of Radiation Oncology, Osaka University
(5)Mitsubishi Electric Corporation
(6)Research Center for Nuclear Physics, Osaka University

Radiation therapy is one of the most effective techniques in cancer treatment. In the treatment planning of irradiation schemes, depth dose distributions in tissues are most important and fundamental data. So far, it was time consuming tasks to measure the depth dose distributions in water phantom (which has almost the same characteristics as tissues) by scanning the ionization chamber or other small detector. From 1995 in our institute, new designed detector has been developed for the dosimetry of the depth dose distribution covering the whole treatment field in a short time without debasing precision. In the previous report, we showed our new designed depth dose monitoring system that allowed quick and precise measurement of photon, electron, proton and carbon beams. Our monitoring system comprised the scintillation fiber blocks as detector, CCD camera and personal computer (Fig.1). In brief, the light generated in the scintillation fiber blocks was monitored by CCD camera with high sensitivity and was taken into personal computer. After the measured data were processed into depth dose patterns, they were displayed at arbitrary planes.

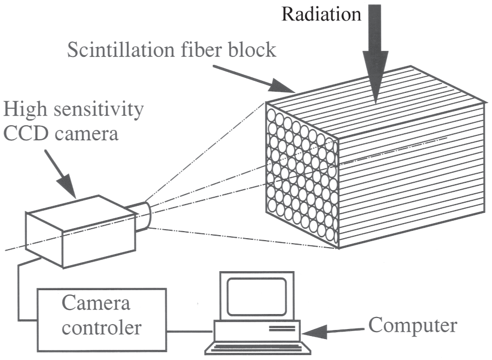

Fig. 1. The schematic view of the depth dose monitoring system.

This monitoring system seemed to be very useful in hospital uses. From 1997, we have improved our system to make them more useful for routine works in radiation therapy. In the radiation treatments, it is required to measure the absorbed dose in tissues with precision of $\pm 2\%$. And detecting system is desired to be more compact. In our measuring system, scintillation fiber blocks are made of polystyrene, which is almost tissue equivalent. The characteristics of the scintillation fiber are summarized in Table 1.

material	polystyrene
density	1.05 g/cm^3
number of H atom	4.82 x 10^{22} cm^{-3} (7.7 wt%)
number of C atom	4.85 x 10^{22} cm^{-3} (92.3 wt%)
number of electron	3.4 x 10^{23} cm^{-3}

Table 1. The characteristic of the scintillation fiber

The most suitable size of the detector was obtained from the results of simulation using the EGS 4 code system[1] to diminish the detector size. More compactness was attained by bending the light from detectors with utilizing mirror, small CCD camera and by rotating the detector along the central axis to be able to measure the dose distribution in all irradiated field. The thickness of scintillation fiber blocks was made thin in comparison with the prototype to increase the resolution. The final outputs were acquired with CRT display or printer plotter. Ionization chamber which has traceability to national standard of Japan is the basic detector in radiation therapy. The depth dose distribution of photon beams (4,10,18 MV) and electron beams (6, 9,12 and 15 MeV) from linear accelerator installed at the Osaka University Hospital were obtained by scanning ionization chamber in water phantom and they were compared with that of our new measuring system in order to estimate the differences. Three dimensional dose distributions were measured with rotating detector by increment of 10°. The time of measurement was greatly reduced from several hours to about 5 minutes. The discrepancy between them was within 2% up to the depth of 25 cm. As the depth dose distribution for the photons and the electron beams concurred well with those of the ionization chamber, we could confirm the suitability of this measuring principles. Various improvements were also made in processing the raw data. The depth dose distribution are expressed at arbitrary sectional planes in the manner of percent depth dose relative to peak value. As a result, the extent of flatness and symmetry can be estimated. We can utilize the standard depth dose data for high energetic photon beams and electron beams with specific energy used in radiation therapy. There are some methods to decide its energy, but they give small differences in each other. Most appropriate method is directly to measure the depth dose distributions of treatment machine. Our experimental data showed that the depth dose distribution of photon and electron beams were easily obtained with sufficient precision in radiation therapy. New designed depth dose meter is expected to be better than the commonly used system. Overview of the system and its specifications are presented in Fig. 2 and Table 2.

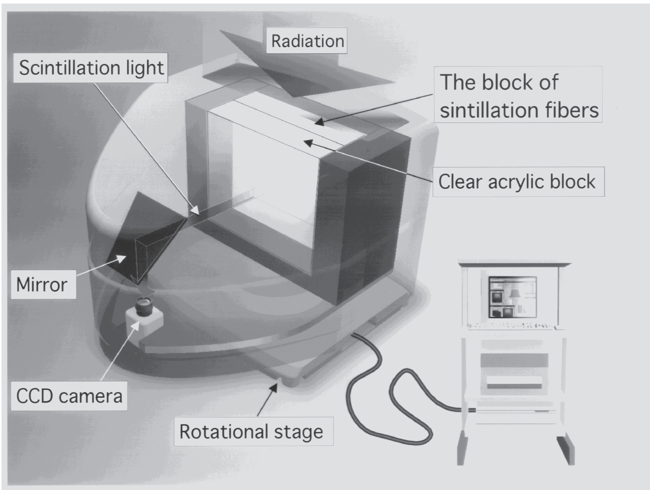

Fig.2. Depth dose meter using scintillation fiber blocks.

Dimensions	Detector	670D x 480W x 520H
Weight	Detector	56 Kg
Range		$\leqq$ 250 mm in depth
Resolution		1 mm
Dose response		$\pm$ 2 %
Required time	2D	10 sec
	3D	5 min

Table 2. Specification for depth dose meter

Reference

1). W.R.Nelson, H.Hirayama and D.W.O.Roger. The EGS4 code system. SLAC report-265,1985.

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