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DOSIMETRY SYSTEM FOR HEAVY-ION RADIOTHERAPY

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Abstract

This paper describes a dosimetry system for the heavy-ion radiation therapy installed at HIMAC facility. Daily check of the dose monitor, a species of the accelerated particles, their energy are carried out every morning. And the dose calibration of the monitor for each patient condition are also carried out every morning. The variations of the monitor responses were less than 2 % during 3 months of treatment term. In order to shorten the time for the check, a simplified dosimetric system for the dose calibration of the monitor was installed from this autumn.

1. Introduction

A radiation therapy using a carbon beam has been started at HIMAC facility from last year[1]. The heavy-ion radiotherapy is expected to be superior to the conventional radiation because of its excellent dose localization and its high biological effectiveness. Then, it is important to irradiate patients as previously planned by a treatment planning system. Around 18 times of exposures are given to the same patient in the heavy-ion radiotherapy. And it takes over one month to finish the treatment. It is necessary to guarantee daily exposure dose to be the planned exposure. In order to guarantee these things, the check of the dose monitor, a species of the accelerated particles, and their energy are carried out every morning. The dose calibration of the monitor for each patient condition are also carried out every morning. These check is very important for the assessment of the irradiation port.

In this paper, the dosimetry system for the heavy-ion radiation therapy installed at HIMAC facility is presented and discussed in detail.

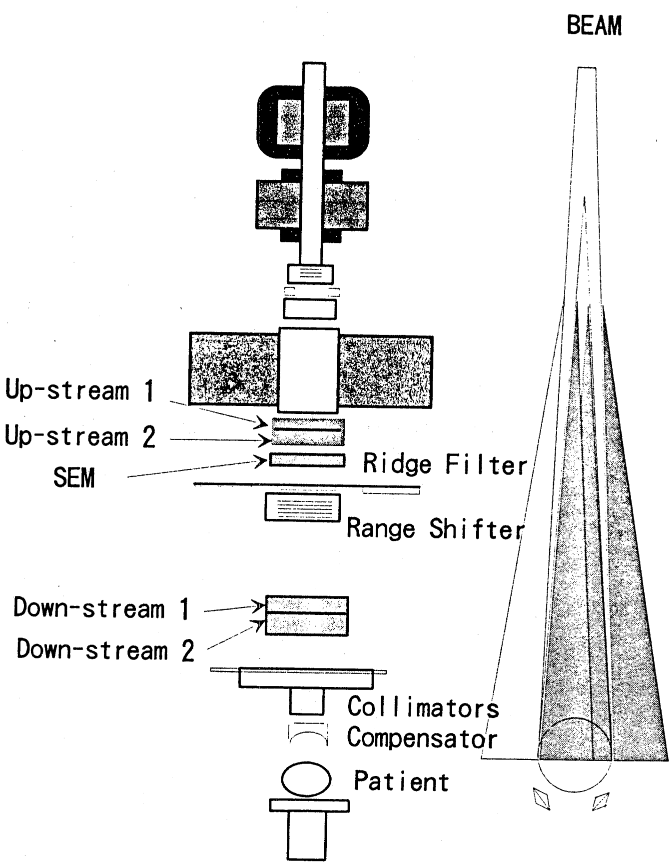

Fig. 1. Illustration of the therapeutic beam port

2. Monitor system

In the HIMAC irradiation course for the radiation therapy, 5 monitors are installed. Fig. 1. shows the illustration of the therapeutic beam port of HIMAC and indicates the location of the monitors in the beam course[2]. Monitors which are shown as up-stream 1,2 and down-stream 1,2 are the parallel plate ionization chamber. The up-stream chamber has two signal electrodes and three high voltage electrodes of the parallel plate ionization chamber. The one signal is fed into a highspeed amplifier and used for monitoring the time structure of the beam. The other output signal is fed into I/F converter which output a pulse for every 1000 pC. The pulse train is input to a preset counter which is connected to a beam shutter for controlling the exposure dose to the patients. We have another dose controlling monitor, SEM (Secondary Emission Monitor). We have anxiety that beams may have a big spike in the beam spill. In that case, accurate dose can not be measured by the ionization chamber monitor because of recombination effects in the big spike. Then, we used the secondary emission chamber for the back-up of the ionization chamber.

At just up-stream of the beam collimator, a down-stream monitor was placed. The monitor is also a parallel plate ionization chamber, and has one signal plane which is sandwiched by two high voltage electrodes. On one side of the signal plane, there are 29 signal electrodes of 20 mm in diameter which are distributed in the guard earth. This ionization chambers are used for roughly monitoring the uniformity of the irradiation field. The other side of the signal plane of the down-stream chamber is a signal electrode which cover the whole uniform irradiation field. This output is used as another back-up monitor of the exposure dose.

Using these monitor system, the irradiation dose to the patients are controlled and monitored.

3. Dose calibration system

Standard procedure of the dose calibration using the above system is as follows;

1) Depth dose distribution of a spread Bragg peak which has 6 cm width is measured by a standard dosimeter. The standard dosimeter is a parallel plate ionization chamber, which is fabricated by Far West Technology, Co.,. We use a binary filter to change a depth in water in the measurements of the depth dose distributions. The binary filter consists of 9 PMMA (Polymethyl methacrylate; Lucite) sheets of 0.5, 1, 2, 4, 8, 16, 32,64 and 128 mm thickness and 10 x 10 cm area. Inserting these sheets in the beam course, the target thickness is changed. The thickness of the PMMA is transferred to water equivalent thickness.

2) The measured dose distribution is compared with a calculated depth dose distribution. From the comparison, variations of the residual range of the carbon beam at the irradiation site and absolute value of the output of the standard chamber are recorded for the check of the beam energy, and the species of the particles. Fig.2 shows the variation of the range of the 350 MeV/u carbon beam checked by the

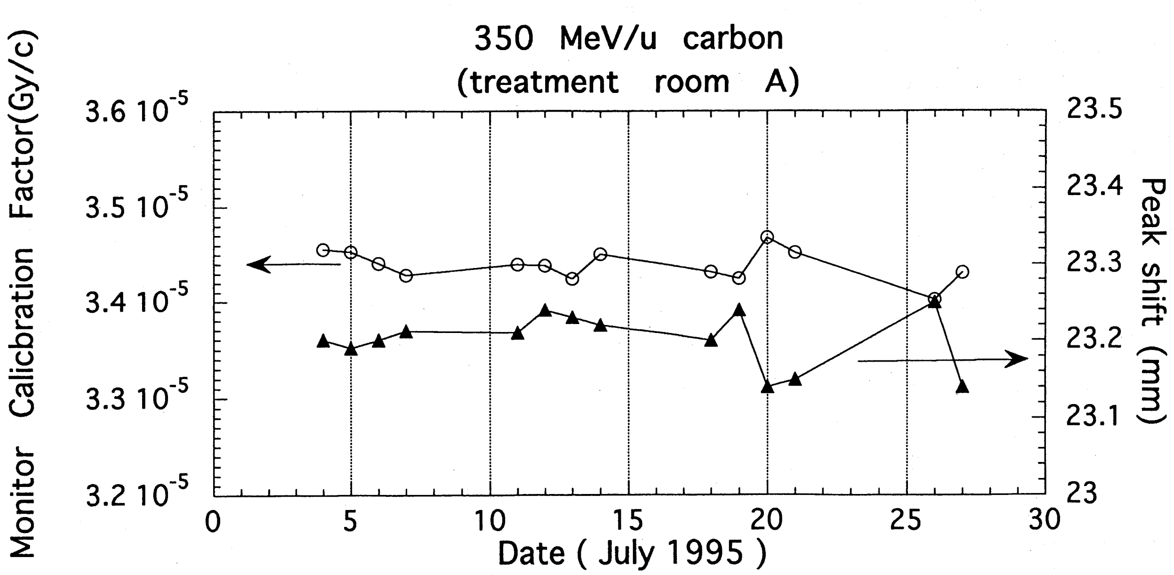

Fig. 2. Daily change of the monitor calibration factor and the peak shift

comparison with the calculation. The variation of the dose at 0 absorber position in the measurement of the depth dose distribution is also shown in the figure.

3) The information of the treatments, the excitation current of the wobbler magnets, thickness of the scatterer, sort of the ridge filter, thickness of the range shifter and so on, are send to the irradiation control computer. And the devices are adjusted according to the transferred information. The thickness of the binary filter is set so as for the residual range of the carbon beam to be half of the width of the spread-out Bragg peak. The standard chamber is set to the center of the spread-out Bragg peak, center of the target volume in the simulated phantom. Dose calibration of the monitor chamber is again performed under this treatment condition several times. These calibration factors are used for the real exposure to the patient.

4. Simplified Calibration

In the actual clinical trials, it takes about 30 minutes for taking the depth dose distribution, and about 5 minutes for taking each dose calibration factor of each patient. It takes an hour and half for the total calibration procedure of 12 patients. This calibration procedure is necessary whenever the initial energy of the carbon beam is changed. We use 290 and 350 or 400 MeV/u carbon beams in one day at HIMAC clinical trials. At that case, it takes 3 hours for the calibration. In order to shorten the calibration time, we are going to adapt a simplified calibration procedure from this autumn. The procedure is as follows;

1) The depth dose distribution is measured by a multi-layer ionization chambers in one exposure.

2) The dose calibration measurement for the each patient condition is performed only at the first treatment. The ratio of the dose calibration factor to the entrance dose of the depth dose distribution is recorded and used for the next treatments. The dose calibration factor for the later treatment is obtained by the ratio times the entrance dose of the depth dose distribution of that day.

From these simplified procedure of the dose calibration, it is possible to shorten the calibration time without making the accuracy of the dose calibration worse.

References

[1] Tujii, H., et al., XXI PTCOG meeting (1994).

[2] Kanai, T., et al., XXI PTCOG meeting (1994).