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SPECIFIC BEAM DELIVERY SYSTEM OF MEDICAL ACCELERATOR HIMAC

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Abstract

A specific beam delivery system for radiation therapy in HIMAC is being designed. This report describes an outline of the beam delivery control system and its operation.

I. INTRODUCTION

HIMAC is a heavy ion accelerator facility designed for radiation therapy[1]. Beam delivery system of HIMAC is very specific and different from the ordinary facilities for experiments of general physics. The treatment control system for irradiation of patients is closely linked with operation of accelerator and beam transport. We report an overall idea of HIMAC beam delivery system and its operation for radiotherapy.

II. CLINICAL REQUIREMENTS

The clinical requirements for radiation therapy are described as follows.

1) At the end of irradiation, three dimensional dose distribution at the tumor volume in the patient must be achieved with an error of less than a few % compared to the precalculation of the dose distribution by the physician. Above all, overdose to the patient must be absolutely avoided.

The tumor of the patient as a target is set at the beam iso-center with an accuracy of less than 1mm. In case of the abdominal organ as the target, it is subject to move by breathing, and the margin of irradiated field should be considered in the treatment planning. Since the shape, volume and position of patient's target and the planned dose distribution are different for each patient, setting of many kinds of devices in the beam port varies at the time of each irradiation. The size of most treatment is satisfactory within a maximum field of 22cm in diameter which is based on clinical experiences at NIRS. On the other hand, small fields such as less than 1cm are often required. Hence, devices of beam port must be accurately adapted for wide range of field size.

2) Irradiation time per patient must be less than a few minutes. The reason is that the patient is immobilized on the couch by the shell or capsule, and immobilization of longer time gives much stress to the patient with illness. Now we are estimating that it takes about ten minutes to set a patient for positioning on the couch. Therefore, treatment time that a patient stays in the treatment room is about fifteen minutes. HIMAC has two synchrotron rings and three treatment rooms (Fig. 1). In the room B, horizontal and vertical beams can be utilized at the same time, and the room A and the room C have the vertical and the horizontal beam course respectively. Accordingly, two beams are delivered to four beam ports alternately. The course of each beam is changed at interval of about ten minutes, and the beam should be immediatly adjusted in compliance with medical requirement for each patient. To realize such a rapid change, all magnets along the beam transport lines are actuated by corresponding treatment schedule and the beam course can be changed by setting only one switching magnet in HEBT(high energy beam transport) line. For these reason, switching magnet must have accurate reproducible setting of field strength and high stability.

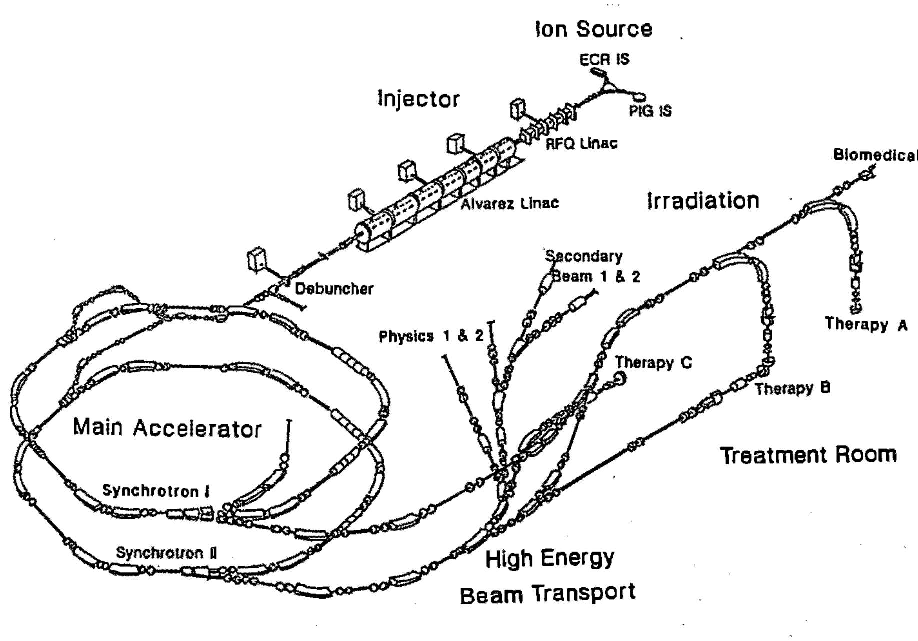

Fig. 1 A schematic view of accelerators and beam lines

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3) HIMAC is expected hopefully to be utilized for more than fifty patients everyday for clinical treatments. In order to realize this, the treatment schedule and the flow of patients must be managed to run smoothly.

4) All systems in HIMAC are designed under the consideration of primary importance for keeping safety of patients and collaborating staffs. Especially, interlock system associated with the beam must be carefully designed from the view point of reliability.

III. TREATMENT SYSTEM

A schematic view of the treatment control network that we designed is shown in Fig. 2. The treatment system of HIMAC consists of the following components.

A. Treatment Planning System

In order to make the best use of heavy ion beam's characteristics, we are developing a three dimensional treatment planning system using a super graphics workstation (TITAN750) [2]. This planning system consists of:

1) defining target volume and critical organs by interactive contouring on Xray-CT, MRI and PET images,
2) determination of directions and shapes of irradiation fields using beam's eye view graphics,
3) calculation and display of three dimensional dose distributions,
4) designing collimators and compensators,
5) generating digitally reconstructed radiographs which are used for patient positioning.

In addition, the treatment supporting computer converts the planning data to the treatment control data, which consist of beam parameters, port data and treatment couch parameters.

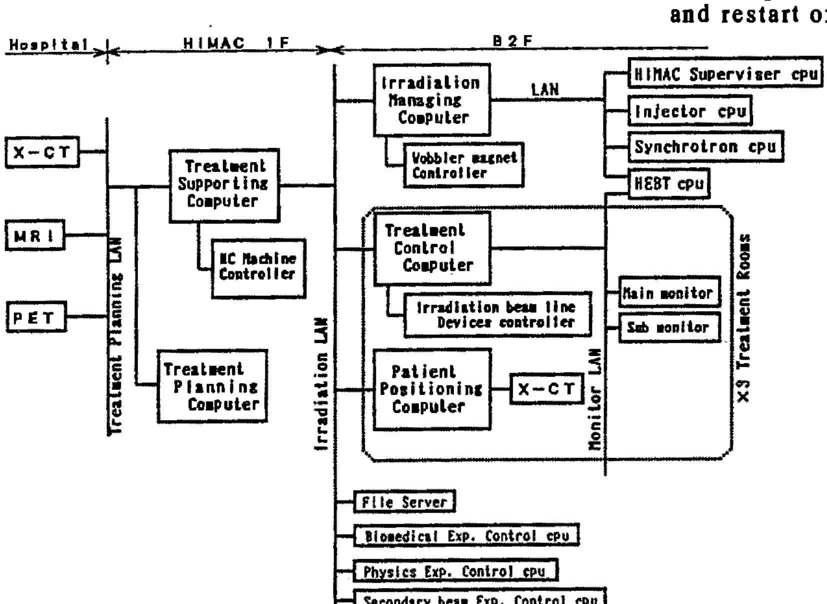

Fig. 2 HIMAC treatment computer network

B. Patient Positioning system

For patient positioning, we usually use the laser pointers, light localizer and digital Xray TVs that are incorporated in the beam port. The three dimensional coordinates of the target are estimated by coordinates of anatomical landmarks in the process of reconstruction by two projected Xray images perpendicular to each other[3]. Referencing the digitally reconstructed radiographs that are generated at the planning, the transfer of treatment couch is determined. The couch is to be operated by the treatment control computer(HP9000/380) linked to the patient positioning computer(HP9000/730) with image devices. Further, CT scanner can be used for the check of patient verification.

C. Irradiation system

Irradiation managing computer(HP9000/380) communicates with HIMAC central supervisor computer. It gives a requirement of the beam course, beam energy and ion species to HEBT controller via supervisor along the schedule. Concerning the responsibility of beam irradiation, we use the name "RIGHT" which means the initiative of opening the neutron shutter and the FCN(one of the Faraday cup monitors) shutter. The irradiation , that is the on/off of the beam, should be under the control of treatment side. Usually, irradiating at the treatment room starts after RIGHT is transfered to the treatment control.

Devices of irradiation beam port (Fig. 3) comprise a pair of wobbler magnets, a beam scatterer, a range shifter, a ridge filter, a multileaf collimator and monitors. They are controlled by the treatment control computer via interface unit.

To protect from accidental irradiation to patients and collaborating medical staffs, interlock systems are carefully built against such occasions as probable overdose, various kinds of troubles in each instrument, change of beam intensity and change of patient's condition including his unexpected movement. Further, quick stop and restart of irradiation are required repeatedly for medical use. In consideration of these things, operation of opening and closing the neutron shutter and the FCN shutter are handled either automatically or manually. They are synthesized in the form of global interlock system which is driven with threefold safety through hardware and software.

IV. OPERATION OF IRRADIATION

A layout of treatment room floor is shown in Fig. 4. Chief radiation therapy technologist(RTT) sitting by the irradiation managing computer can always look over the treatment hall and watch the ITVs coming from treatment rooms. In addition, the status of patients and beam lines are displayed on his console. So he manages the schedule of irradiations for smooth running.

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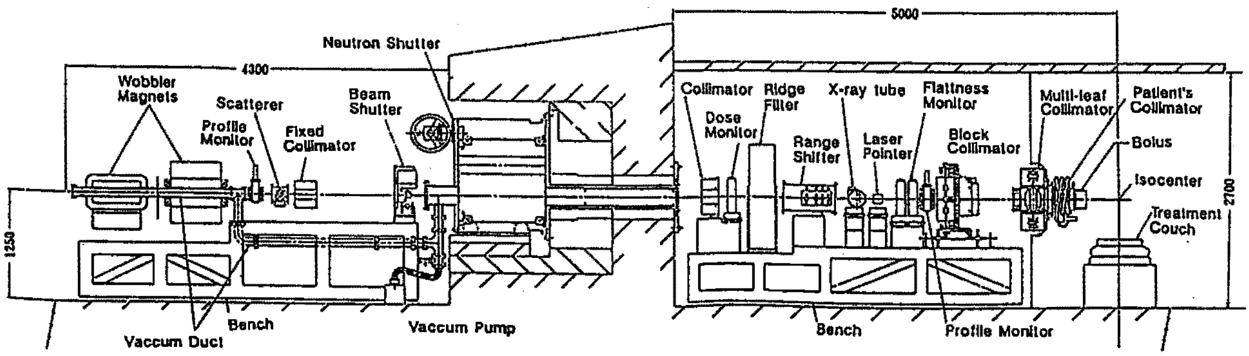

Fig. 3 A layout of beam port in the horizontal line

In ordinary clinical use, every morning, at first, RTT calibrates monitors in the same conditions of various devices just as the irradiation for each patient. Each parameter file which contains beam course, beam energy, ion species, setting parameters of magnets and so on is saved in the treatment control computer. This file name is checked before corresponding patient's irradiation, and the irradiation starts in the same condition at the time of calibration. The patient's irradiation starts after these.

Following the check of patient's ID-card, devices of beam port are automatically set on the starting status. While the RTT is setting the patient on the treatment couch, operators of HEBT adjust the beam up to the position before the neutron shutter, and keep waiting as the beam is stopped by FCN shutter. After the patient's setting, the RTT goes out from the treatment room and closes the shield door. The status of shield door is connected to global interlock system. And next, the RTT requests the RIGHT to HEBT. After the RIGHT is transferred to the treatment control, he opens the neutron shutter. It takes about ten seconds to open. Then RTT opens the FCN shutter which takes less than one second, and the irradiation starts. Besides global interlock system, whenever RTT wants to suspend irradiation depending on the patient's condition, he can shut the beam and restart quickly afterward. Once the dose counting of main-monitor reaches preset counts, kicker magnet kicks off the beam, and then FCN and neutron shutter are closed through the interlock system. A main-monitor system is always backed by sub-monitor system. Then RIGHT returns to HEBT with the data of request to next beam course. The data of irradiation records such as final counts of monitors, times of suspension, positioning images and status of port devices are preserved for each patient.

Now, we are designing and developing the software and hardware to control the beam for radiation therapy in HIMAC. The clinical trial will start in 1994.

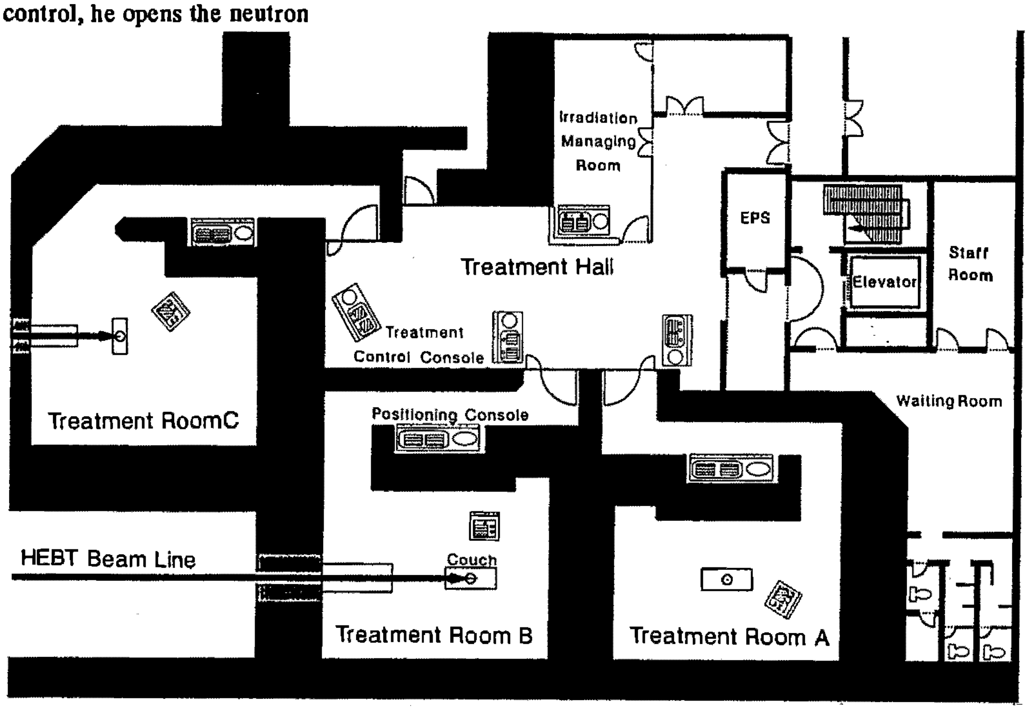

Fig. 4 A schematic view of treatment floor (HIMAC B2F)

References
1) K.Kawachi et al., Proc. 2nd Int. Sympo. Advanced Nuclear Energy Research, p.362 (1990)
2) M.Endo et al., Proc. of Int. Conf. on MBE, vol.29, p.317 (1991)
3) S.Minohara et al., Proc. of Int. Conf. on MBE, vol.29, p.859 (1991)