NIRS PROTON THERAPY CONTROL SYSTEM

Tetsuo Inada, Kiyomitsu Kawachi, Tatsuaki Kanai
Hirotsugu Ogawa, Yoshikazu Kumamoto and Takanobu Yamada

National Institute of Radiological Sciences

1. Introduction

The possible application to cancer therapy of heavy atomic particles accelerated to a few hundred MeV per nucleon shows interesting aspects from the physical point of view. The low scattering and the favourable depth-dose relationship of beams of such particles have stimulated investigators at Berkley, Uppsala, Moscow, Leningrad and Boston to apply their accelerators at these places to radiological experiments. Many therapeutic techniques have later been developed. Now, a proton therapy project has started for the first step of "light ion therapy" in Japan. NIRS cyclotron is based on a 200 cm pole diameter magnet and its design goal for the highest proton energy is 100 MeV. However, at the present status, the rf and magnet power supplies limit it up to 70 MeV. The increase in these power supplies will be done later on to obtain at least 90 MeV proton beam.

2. Proton Beam Delivery

60-70 MeV proton beam was provided by NIRS cyclotron. The collimated beam passed invacuo, except at the monitor space, to the experimental area situated at a distance of 26 m from the accelerator. Before the beam entered the experimental room through a channel in the thick wall of cyclotron vault, it was roughly collimated by a pair of quadrupole magnets. Another triplet of quadrupole magnets located after 15 degree bending magnet and provided the desired parallelism of paths of the protons on their ways over the optical bench used to align the experimental apparatus. The beam duct arrangement in the experimental room is shown in Fig.1. The parallel beam was extracted into 20 cm air gap at the central position where the transmission ionization chambers were located. In the down stream part, a collimator-shaped spot beam was swept over the treatment volume by two bending magnets in orthogonal planes, while the depth of penetration was adjusted by energy modulation in air space after the scanning beam duct in order to spread out the Bragg peak.

3. Spot Scanning System

This system aims to scan a spot beam in a required field shape as discrete fashion which could be called "spot scan" in contrast with "linear scan". The block diagram of the system is shown in Fig.2. It is controlled by an interface named Beam Control Interface(BCI) and aided by 64 kbite computer(TOSBAC 40-C) in order to provide the irregular and/or non-uniform field. The field design data are put in by the use of a graphic tablet and displayed on a CRT for certainty. The data are then fed into BCI and the field planning is divided in square elements of raster, which are converted in turn to the input of the power supply of the scanning magnet. A typical run of BCI and the response of the scanning magnet are shown in in Fig.3(a) and (b), where one line is supposed to be divided into 6 elements. The transit time required for the move to the next spot position was around 10 msec before the field stability of within 10^{-4} was achieved at the designated position.

For 100 msec stay time at each spot, about 1pA beam is needed to transfer the dose of 100 rad in 1x1 cm area and the dose given at each spot is counted up by a quick integral system. Beam intensity monitors and interlocks were designed to respond to the larger beam fluctuation in "fail-safe" fashion.

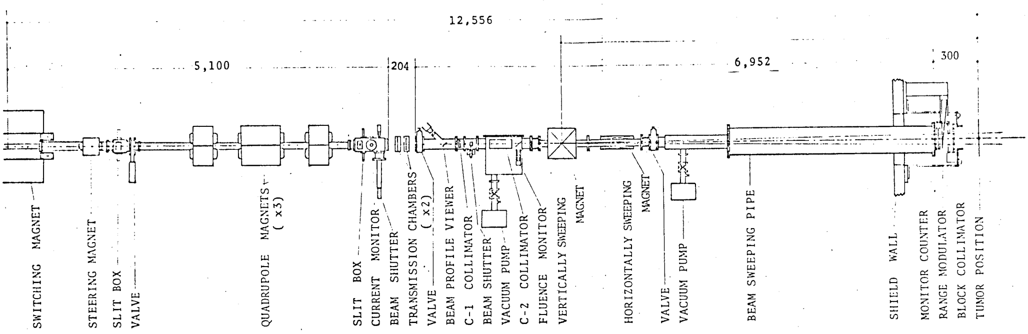
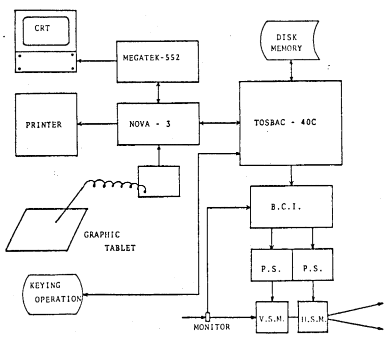
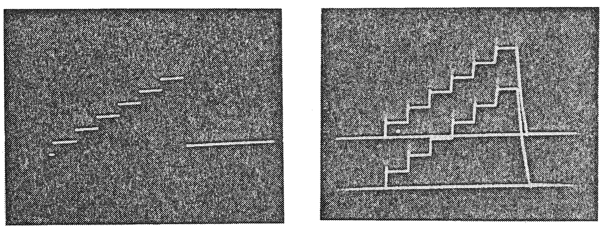


Fig.1. Beam duct arrangement for proton therapy.





(a) (b)

Fig. 3. BCI output and scanning magnet response; each step is 100 msec duration.

Fig.2. Spot scanning data input and controll system.