DESIGN CONSIDERATION OF NEUTRON THERAPY FACILITY UTILIZING EXISTING CYCLOTRON

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ABSTRACT

A facility for testing the effectiveness of fast neutrons for the treatment of malignant tumors will be constructed at the Institute ofNuclear Research, Academia Sinica. Neutrons are produced by the bombardment of 30 Mev protons on a semithick beryllium target. The design consideration of the collimation system, target assembly, dosimetry and beam control aregiven.

1. INTRODUCTION

The use of cyclotrons for radiotherapy purposes is not new. In fact, fast neutrons has been used to treat human cancers on a continuing basis since 1966 when the MRC cyclotron was made available for radiotherpy at the Mammersmith Hospital in London. Since then, various centers throughout the world have also begun clinical trials with fast noutrons. The usefulness of these studies has been to show that neutron therapy can be carried out with optimstic results.[1] Nation wide there are four cyclotros in operation, and most of these machines are used for isotope production or basic research only. With the installation of the neutron therapy facility, the INR cyclotron will be mainly used for production of radioactive isotopes and for generation of neutrons for treating cancer patients.

2. COLLIMATION SYSTEM

Available funds and limited room condition do not permit either a isocentric or a verticalneutron therapy beam, and decision was taken to use, at the initial stage, a fixed horizontal beam. The collimation system, Fig.1, consists of sheilding and collimators. The area around the target and the ionization chamber is covered with a cyclindrical shielding constructed from 20cm thick pure iron and 25cm thick borated wax, which is 60cm long. The primary collimatormade of pure iron is position ed immediately beyond the target to delimitate the largest available field size(20×20cm), which is 8cm long.

Following the cyclindrical Shielding a shielding in cone shape is provided. The inner parts, i. e. secondary collimators, which is adjacent to its axial aperture into which the interchangeable polyethylene concrete collimator is inserted are constructed from high density(1. 4 g cm^{-3}) borated wood. To achieve therequired attenuation, each collimators is 60cm long. The field sizes (5×5-20×20 cm) are defined with these collimators. The collimator system will allow remote motor driven angulation of the collimator.

The outer parts consist of alternate layers of borated polyethene and pure iron. The total length of the layers is 58 cm, 3/5 of them are iron, having outer diameter of 44-50 cm. The remainder surrounding the layers is filled with borated wax in cone shape.

The system is designed at 125 cm SAD with distance from the end of the collimator to the surface of the patient being 32 cm.

In addition, a gamma radiation shutter made of lead, 5 cm thick, is supplied, which located in the front of collimators in order to reduce activities in and around the target. one mirror with lamp is used for the field illumination.

As the beam is fixed horizontal, the treatment coach is designed to move on multiple axes, rotate and tilt in order that the patient may be adjusted to the beam.

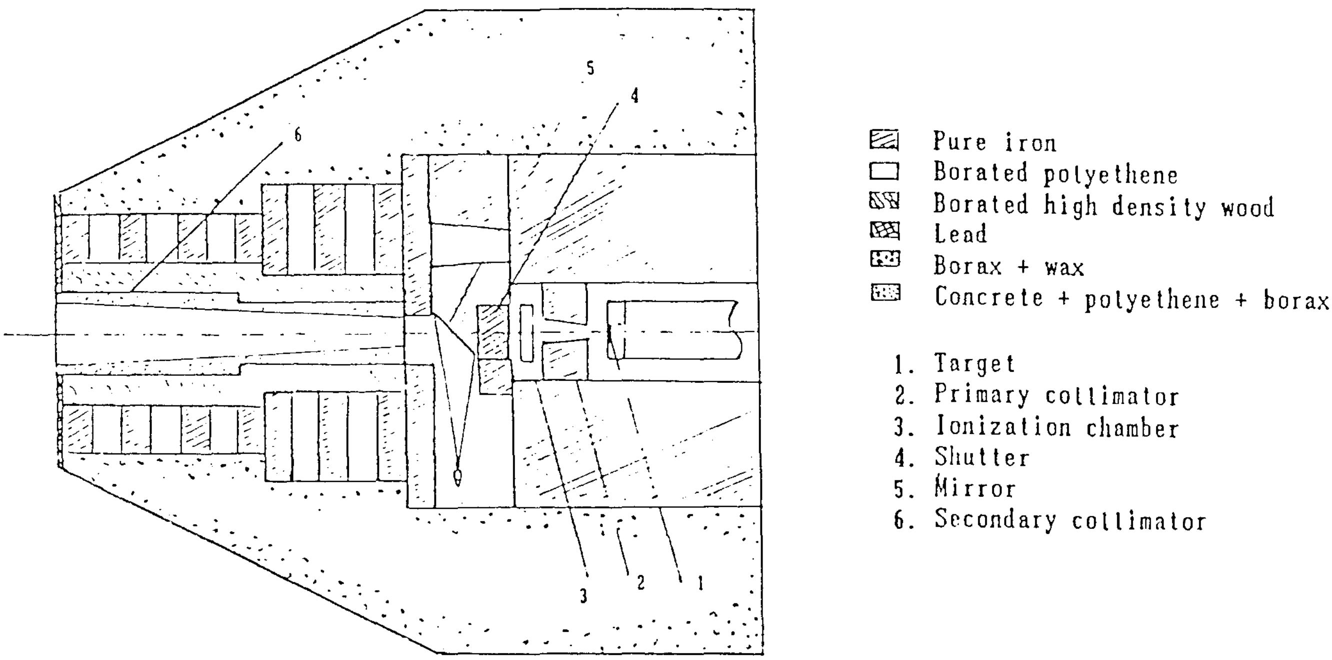

Fig.1 The collimation system.

3. TARGET ASSEMBLY

Neutrons are produced by bombarding a semithik beryllium(Be content over 99%) target with 30 Mev protons. The target housed in a water cooled aluminum holder consists of 0.4 cm in thickness, 2.5 cm in diameter of beryllium backed by 0.17cm graphite." For the 30 Mev, 50μa proton beam current, a dose rate of 28 rads minute with a depth for 50% dose of 10.5 cm is expected.

The position of the beam on the target is monitored by a graphite defining iris consisting of four insulated quadrants, from each of which the current can be monitored separatedly. A electron suppressor is supplied.

In selecting the materials for manufacturing the target assembly care must be taken to minimize the induced activities produced by neutrons. The titanium is preferable to aluminum and steel.

4. BEAM CONTROL

A semiautomatic set up system of fast neutron therapy is considered. In the design, care is taken account of safety in beam hadling. The relevant parameters monitored in the console located in the control room are the integrated and instantaneous beam current on the target, integrated ionization current form the transmitted ionization chamber, instantaneous beam current on the beam defining iris and the elapse time. Also one beam stoppers located before the target and the gamma radiation shutter are controled from the console.

A microcomputer is applied to verify the patients setting up, to store the patients records and relevant cyclotron parameters. For each treatment program, the dose to be delivered are preset prior to patient treament in the primary beam. In addition, a talkphone is provided to communicate with the cyclotron control room and the treatment room.

5. DOSIMETRY

Neutrons emitted form the target are then detected with a transmitted ionization chamber located behind primary collimator. Two electrodes mounted in the chamber, each of which collects ionization charge from two air filled cavities, are connected to an independent dose monitor system.

The chamber must be callibrated with

standardized one prior to treatment of patients.

Extensive radiation dosimetry measurements should be carried out to evaluate the neutron beam characteristics including central axis depth dose, off axis ratios and dose buildup, etc.

6. REFERENCES

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2) Miguel Awschalom and Ivan Rosenberg, "The influence of target thickness and backstop material on proton-produced neutron beams for radiotherapy" Med, Phys. 7(5), Sept. /Oct. pp.495-502 (1980)