THE CYCLOTRON BASED FAST NEUTRON THERAPY FACILITY OF SINR

Zhang Jian, Chang Hongjun, Wei Jing
Xiao Huichang, Guo Bin

Shanghai Institute of Nuclear Research,Academia Sinica
P.O.Box 800-204 Shanghai 201800,China

A neutron therapy facility using a compact cyclotron (CYCLONE-30) is built at Shanghai Institute of Nuclear Research . The neutrons will be produced by the bombardment of 30 MeV protons on a beryllium target. This paper describes the installation with different experiment areas, beam transport line ,control system,collimators, Dosimetry system, "Chair" for the patient and the main features of this neutron therapy facility.

Introduction

An IBA CYCLONE-30 cyclotron is under installtion at SINR,which will be used for the production of radioactive isotopes and generation of neutron for cancer therapy.Fast neutrons are produced by bombarding a semi-thick beryllium target with 30 MeV proton. The dose rate of 30 CGy/min can be delivered for 10x10 cm^2 field at SSD of 125 cm from the target with 60 μA beam current. Such a neutron therapy facility will meet the current needs for the hospitals and research institutes in Shanghai and East China.

General Layout

A new bielding is essentionally completed for the cyclotron with the different experiment areas. For the neutron therapy project, some rooms such as the treatment, patients waiting, clinical and control room are available.Fig.1 shows the overall layout of the facility.

For the first stage, a fixe horizonal beam is adopted , but a basementjust under the treatment room is available for the use of vertical beam with a 90° bending magnet in the future. A chair base has been designed for the special requirement such that a patient can be immobilized in different positions during treatment.It can be moved in three-dimension space(forward and back , from left to right, up or down) and rotated around the central axis. All movements and rotation are controlled by the stepping motors and a system with optically coupled modules has been devised to monitor accurately the positions of the chair. The positional accuracy is 1 mm for the linear movement and 1 degree for the rotated angle .

All access to the radiation areas is via shielding doors rather than a maze mainly to save space. For the same reason, a single door is used for the treatment room and the other. In shielding design, limestone aggregate was used to minimize neutron activation . All conduits and air penetreating the shielding walls have multiple bends . The radiation areas are air conditional with negative pressure.

Transport Beam Line

The proton beam is extracted from the cyclotron by a stripping foil and deflected 22.5° into the beam line for the neutron therapy.

With the aid of transport computer program to calculate the beam optical properties, it was possible to optimize the beam through a normal 7-10 cm diameter beam tubes and deliever the beam to a maximum uniform size at the target . The line contains vaccum valve, two steering diapoles, a dual quadrupole, two slit devices, beam probe and beryllium target. Also a set of vaccum system is needed .

The maximum envelops of the proton beam along the line are 3.7 cm in horizonal and 4.25 cm in vertical plane .Finally, the beam is focussed to a 1.5 cm diameter spot on the target .

The beam line about 5 M in length was manufactured from stainless steel.

Collimator system and Target

The collimator system was designed with a Source-skin distance of 125 cm ,it consists of shielding, primary collimator ,interchangeable collimator,ionization chamber, shutter and mirror.Fig.2 shows the complete collimator assembly.

Neutron beam from the target is collimated first by a 7 cm thick pure iron primary collimator . The treatment head with the total length of 59.5 cm was designed in three sections , the outer is the shielding assembled by alternate layers of boarted polythene and pure iron. The inner is the interchangeable collimator, by which the field size will be defined, the intermediate is the secondary collimator,that can be rotated around the central axis , both parts are manufactured from the borated polythene rather than the borated wood .

This material is selected to lower neutron energy by elastic scattering with the hydrogen muclei , which are conducted of polythene containing approximatly 3 - 5% of boron.

To improve the skin sparing , 4 mm thick beryllium is used for the target, which is housed in a water cooling holder. It was designed isolating from the ground electrically for the measurement of proton beam current on the target .

There is a specially closed loop deionized water system for the target to confine higher contamination level. A small chiller unit ensures that the cooling water is below 25 degree C under all conditions .

To attenuate and reduce the residual activity , the target and treatment head are mounted in the wall between cyclotron vault and treatment room.

Control system

The neutron therapy facility has itself control system separated from the cyclotron , which can perform the following tasks:

Personal and equipment safety, the interlock including the key lock ,doors,cooling water,probe, lead shutter and radiation level;

Power up/down of beam line elements;

Setting and monitoring of magnet current;

Reading proton/neutron monitors and displays the interlock lights;

Selection of operation models;

Push button for treatment start or stop in case of emergency;

Set-up the treating time and dose for patient therapy ;

At the end of treatment,the proton beam stopped automatically via the cyclotron control system .

A computer will be used in this system for reading and storing cyclotron parameters,facility status, treatment prescriptions, treating time and dose individually.

Dosimetry System

A dosemetric measuring system has been designed for the dose information to be obtained in several hours. The system consists of water phanton ,X-Y scanning mechanism,ionization chamber ,linear conversion amplifiers, stepping motor controller and a computer interfaced with A/D and D/A converters.

The portable water phanton is made of perspex with a internal volume of 40×40×45 cm^3. The ionization chamber is mounted on the scanning mechanism and moved under the computer control within the phanton to a spatial resolution of 0.1 mm . The ionizatiion chamber current is converted into DC voltage signal at the computer input by a linear amplifier,the computer allows the writting of all planning program in language C for the information acquisition and driving the stepping motors.

Present status and Plan

The new building is essentically completed. Cyclotron and some parts of neutron therapy facility have been installed. Cyclotron acceptance tests are planned in this winter and preliminary measurements and dosimetry work will be begun next year .

A dose rate of 30 CGy/min with the depth dose of 10.5 cm at SSD of 125 cm for the field 10×10 cm^2 is expected .

This work is supported by Shanghai Science Technique Development Fund.

Reference

1. R.C.Barrall et al, Trans.Nucl. Sci.Ns-30, No.2, 1777 (1983).

2. D.O.Bottrill et al, Phys. Med. Biol. Vol.20, No.6, 980 (1975).

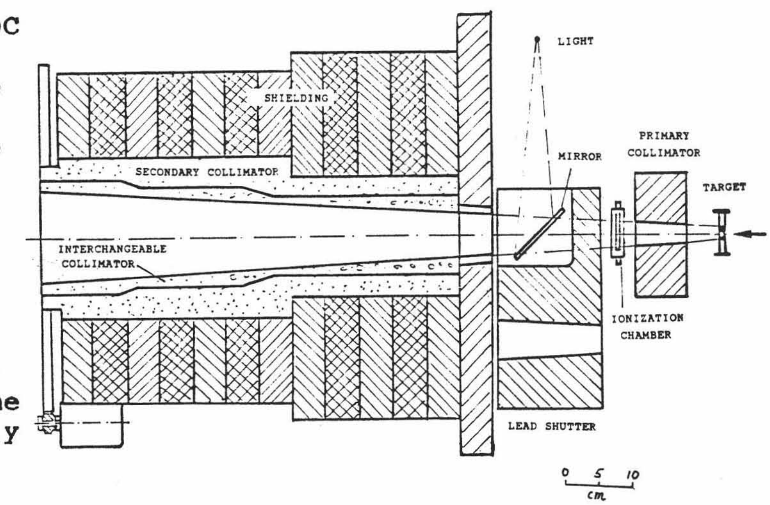

Fig.2 COLLIMATOR SYSTEM AND TARGET

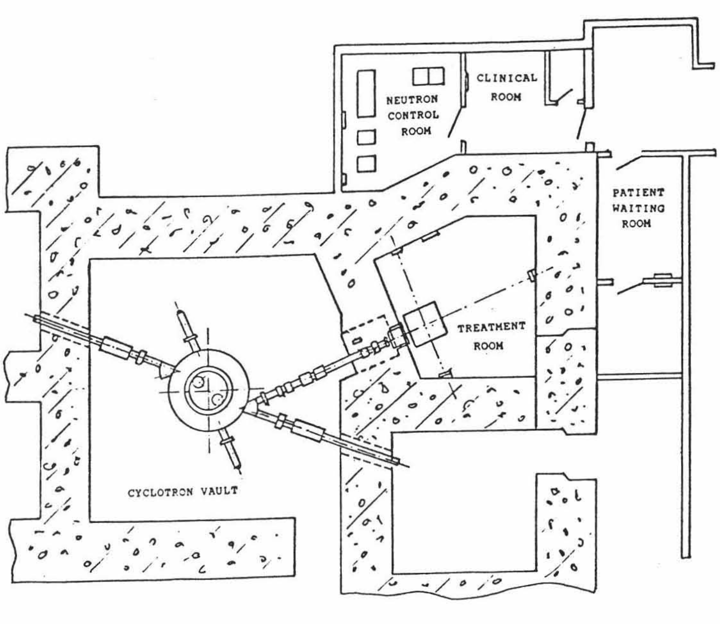

Fig.1 GENERAL LAYOUT OF NEUTRON THERAPY FACILITY