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WERC and Present Status of Proton Therapy Project

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INTRODUCTION

Wakasa-wan Energy Research Center (WERC) is a foundation authorized by MITI (The Ministry of International Trade and Industry) and STA (The Science and Technology Agency) in 1994. The overall aims of WERC are to contribute to the creation of active local communities and to promote the development of science and technology.

Since November 1998 WERC has administered and managed the institute built in Tsuruga City by Fukui Prefecture (Fig. 1), that has four sections, the exchange personnel section, the training section, the general research section and the radiation research section. In the radiation section the accelerator complex (tandem/synchrotron) is installed for the multipurpose research as physical science, engineering, biotechnology, and medical science. Especially, the medical application of accelerators, such as proton cancer therapy is one of the important fields to be intensively researched, which makes a direct contribution to the regional community. This paper describes the accelerator complex and the present status of the project of the proton therapy in WERC.

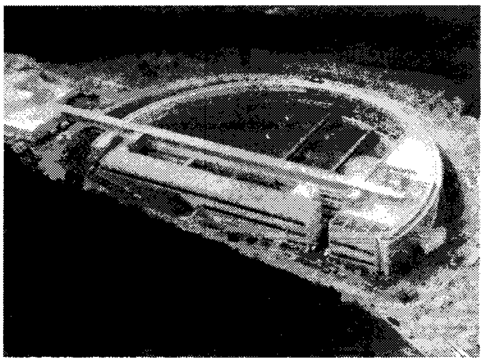

Fig.1 WERC

ACCELERATORS

The WERC accelerator complex consists of two negative ion sources, a tandem accelerator, a synchrotron, low-energy transport beam lines and high-energy ones, as shown in Fig. 2.

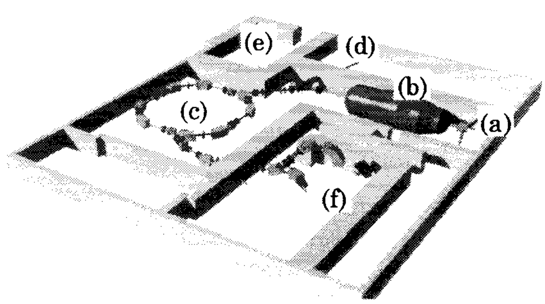

Fig. 2 WERC accelerator complex
a) negative ion sources, b) tandem accelerator, c) synchrotron, d) e) irradiation room 1 and 2, respectively for low energy beams, f) irradiation room 3 and 4 for high energy beams

One negative ion source is for protons and carbons that uses plasma of xenon confined by a cusp magnetic field to sputter negative ions out of the target material in cesium vapor that reduces the work function of the target. As the target, titanium hydride is used for negative hydrogen ions and graphite for negative carbon ions. The other generates negative helium ions by charge-exchanging reaction occurring in the vapor of alkaline metal.

The tandem accelerator is a Schenkel type with the maximum terminal voltage of 5 MV. It functions as the injector to the synchrotron and also provides ion beams of low energy to the irradiation rooms 1 and 2. The spread in beam energy is expected $4 \cdot 10^{-4}$. The acceleration energy can be varied continuously in the range from 1 to 10 MeV for protons and from 2.5 to 25 MeV for carbon ions. The argon gas stripper performs the charge transfer from negative ions to positive ones in the tandem accelerator. Carbon foils installed at the exit of the acceleration tube make the charge transfer for carbon ions from C^{4+} to C^{6+}.

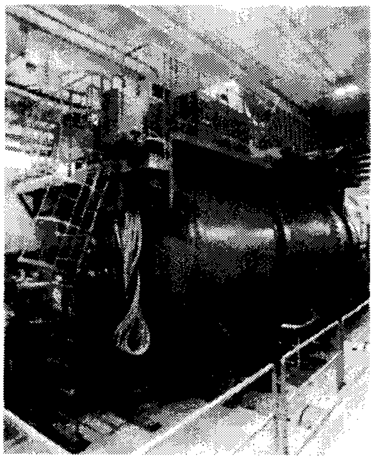

Fig.3 Tandem accelerator

Fig. 4 Synchrotron

The lattice of the synchrotron is the separated function type. The maximum magnetic field of the bending magnet whose curvature radius is 1.91 m and deflection angle is 45 degrees is 1.12 T, which is needed for the beam energy of 200 MeV for proton and 55MeV/u for helium and carbon. The injection of the ion beam from the tandem accelerator to the synchrotron is performed by the multiple turn injection method using a septum magnet, an electric inflector and two bump magnets. The injected ion beam is accelerated using the untuned type RF cavity that employs Fe-based nanocrystalline FINEMET cores. The extraction of ion beam is made by the diffusion resonant method. This method keeps the separatrix constant and applies the narrow band RF noise to diffuse the beam to the separatrix. Due to the effect of the constant separatrix, the orbit gradients of the extracted particles at the deflector position are constant without dynamic control of the magnets. As a result, the beam position does not change and the time-integrated emittance can be kept very low.

The 200 MeV protons could be accelerated in May 1999 and the accelerators are under adjustment for better performance.

PROJECT OF PROTON THERAPY

WERC plans to start the proton cancer therapy in 2001. The maximum number of patients treated per year with proton beams is expected to be about 50. Patients introduced to WERC will be hospitalized in a regional medical institution and arrive at WERC for each proton fractionated irradiation. As far, the equipment relevant to irradiation system has been fixed, the staff has been employed and committees have been held regularly in order to realize this project.

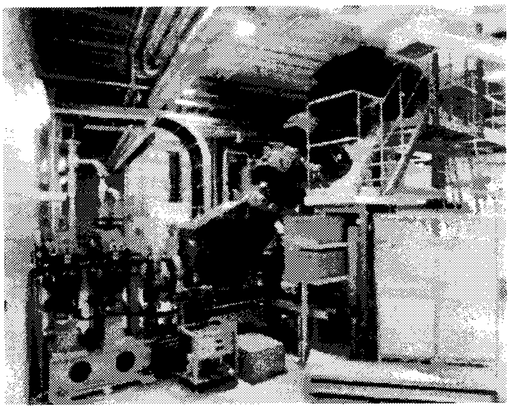

Fig. 5 Vertical beam line

One vertical beam line and one horizontal beam line for the proton cancer therapy are to be installed in the irradiation room 3. Fig. 5 shows the vertical beam line constructed partially. The maximum beam current and energy of proton beams are expected to 10 nA and 200 MeV, respectively. The irradiation field will be generated by using two wobbler magnets whose size is 10 cm diameter. The X-ray computed tomography system (X-ray CT) which is also to be installed close by the irradiation system. This X-ray CT will be used for the therapy planning and the patient positioning. The final design of the irradiation system is now in progress.

The minimum staffs required for the project are two medical doctors, two medical physicists, two radiological technologists and one nurse. One medical doctor, one medical physicist and one radiological technologist have been already employed. The rest of the staffs are planed to be employed by 2001.

In order to put the proton cancer therapy project forward, WERC has hold two committees, the proton cancer therapy promotion and examination committee and the cancer therapy expert committee. The former is composed of representatives of regional medical institutions in order to construct a cooperative system and keep their good understanding of this proton therapy project. The latter consists of experts on particle therapy, radiotherapy and accelerator physics and discusses the details of equipment, medical protocols and the organization of an ethical committee.

In the irradiation room 4, another horizontal beam line will be installed for medical physics, radiobiology and general physics. Using this beam line, the research and development of the three-dimensional dose distribution measurement and the advanced irradiation system including the spot scanning technique are planed.

WERC will be able to offer the place to train persons engaged in the proton therapy and perform technical assistant for the newly constructed medical institutions for the wide spread of the proton therapy.