Proceedings of the 9th International Conference on Cyclotrons and their Applications
September 1981, Caen, France

PERFORMANCE OF THE MUNICH CYCLOTRON

E. Huenges, H. Muthig, H. Morinaga.

Department of Physics, Technische Universität München, D 8046 Garching, W-Germany

Abstract.- The Munich compact cyclotron is mainly used for the production of radioisotopes by bombarding internal targets with light ions. It is reported about a high power rotating target for the 22 MeV proton beam with a beam current of 500 µA applied to the production of strong radioactive sources, and about the new tritium storing and handling system, which allows the acceleration of tritons in the cyclotron without additional risk.

1. Introduction.- The Munich AEG compact cyclotron is a fixed energy machine with four straight sectors having a bending limit of 22 MeV/amu. An internal ion source produces light ions with large beam currents. As the beam extraction ratio does not exceed 60 % due to the small turn separation of the machine, the cyclotron is mainly used for the production of radioisotopes with internal targets. The rf-system allows a total beam loading of about 20 kW. Two projects have been pursued intensively in the last time. The reliable handling of high power proton beams with beam currents up to 500 µA and the acceleration of tritons using a new concept for a safe tritium storage system.

2. The 12 kW rotating target.- In Mößbauer spectroscopy in biophysics and in solid state physics ^{57}Co-sources with an activity of several Ci/mm^2 are needed for some experiments. High beam currents are necessary, to produce such strong radioactive sources. Therefore, an internal water cooled target, as schematically shown in figure 1, was constructed, which enables the handling of the

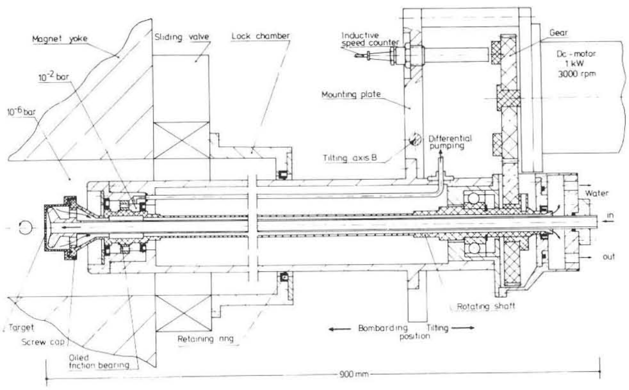

Fig. 1 : Schematic view of the rotating target. All crosshatched parts are rotating.

large beam losses in the target. The rotating system is inserted in a valley sector of the cyclotron magnet instead of the extraction septum.

Some of the characteristic technical data of the target system are given in the following. The rotor is driven by a dc-motor with 1 kW power output, which is necessary to overcome the friction losses of the bearings and sealings and the eddy current losses in the rotating parts, induced by the magnetic field inside the cyclotron. The rotation frequency is 3000 rpm, which must be so high to avoid local, instantaneous melting processes on the target surface. The pressure in the vacuum chamber is $2 \cdot 10^{-6}$ mbar. All static water and vacuum sealings consist of viton, all moveable ones are retaining rings; the rotor sealing is improved by differential pumping (10^{-2} mbar). The pressure difference of the cooling water of 5 bar yields a quantity of flow of 4 m^3/h through the narrow gap on the rear of the 3 mm thick copper backing of the target. Due to this effective cooling and due to the high rotation frequency a beam power of 12 kW is admissible on the target.

The geometry and structure of the irradiated part of the target head is shown in figure 2. The diameter of the target foil is 50 mm, the irradiation angle is about 5°. The target material - in our case ^{58}Ni for the ^{58}Ni(p,2p)^{57}Co reaction - is electroplated on a gold-plated copper backing. The target height is 30 mm, which moves the viton ring and the teflon friction bearing of the water inlet away far enough from the bombarding point , as both materials are destroyed by neutrons, which are intensively produced by (p,n)-reactions in the forward direction.

The target head is coupled vacuum tight to the rotor with a gear screw cap, which can be removed

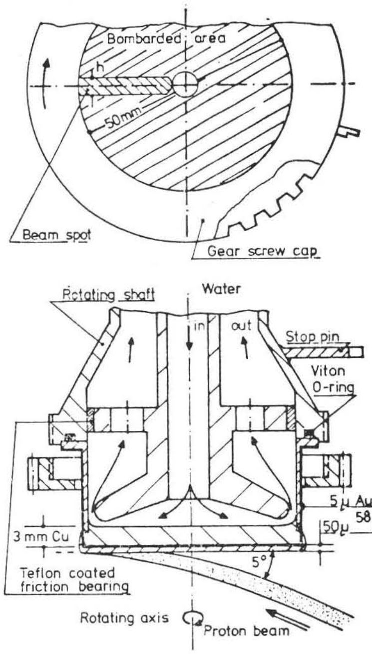

Fig. 2 : Target head and irradiation geometry

by remote control. Passing a vacuum lock chamber the target arm can be brought by aid of compressed air pistons into the bombarding position. After finishing the irradiation the target arm is tilted outside the vacuum chamber into the vertical position; than, the target is shooted in an automatically closing lead box, in which it can be transported tothe hot cells for further chemical processings.

With our device long term irradiations have been performed of about 10 days using a 22 MeV proton beam with 450 μA - corresponding to a beam power of 10 kW-. This yields a total charge of 400 Coulombs on the target resulting in an activity of 2 Ci ^{57}Co. The total dose rate on the target after such an irradiation is about 200 r/h.

3. Triton acceleration.- Neutron rich isotopes can be produced very efficiently via (t,p)-reactions. To guarantee a safe handling of the radioactive gas supply for the ion source, a new concept for storing the tritium in a non gaseous phase was develloped [1].

The tritium gas is filled in two stainless steel vessels,were it is absorbed by two Zr-Al getter pumps [2]. The tritium partial pressure in the steel vessels is below 10^{-10} mbar at room temperature, but it raises to about 10^{-2} mbar at temperatures over 500 °C. Thepartial pressure depends on the totally absorbed quantity of tritium; which was at the beginning about 5000 Ci. By heating the the getter material tritium can be released in well defined quantities, as after switching off the heater, the tritium is absorbed again.In the ion source a low pressure gas discharge is produced with a mixture of nitrogen and a few percentage of tritium. Only the tritons are extracted and accelerated to 7.2 MeV, the beam current is about 20μA To diminish the radioactive waste, especially from the pump oil, a closed vacuum system with no gas outlet was built up, as shown in figure 3.

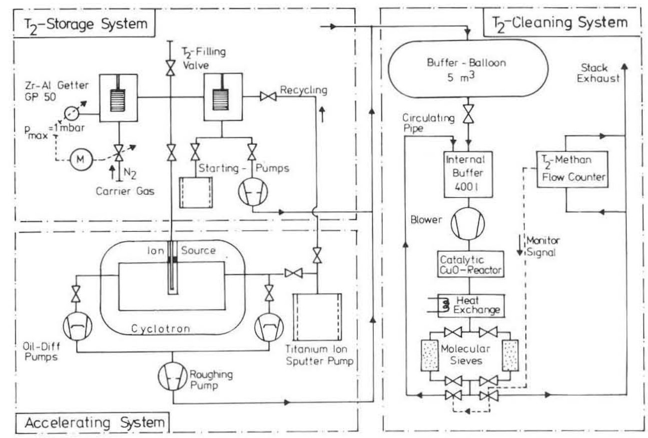

Fig. 3 : The tritium handling system

The vacuum pressure in the cyclotron is maintained during triton acceleration only by one titanium ion sputter pump with a pumping speed for nitrogen of 2000 l/s. The oil diffusion pumps are closed by valves during this time. Additionally, the exhaust air of all roughing pumps, glove boxes and supplementary devices is stored in abuffer. Before releasing to the open air, it is cleaned several times in a catalytic CuO-reactor with following molecular sieves, till the amount of tritium, measured by a methan gas flow counter in the stack exhaust, lies below the allowed limit. With similar counters the air inall rooms of the accelerator building is monitored. Since two years triton acceleration is performed with the permission of the Bavarian ministry for environment. No major failure happened inthis time.

The isotope mainly produced with the triton beam is ^{28}Mg using the (t,p)-reaction on ^{26}Mg. This isotope is applied very succesfully in tracer experiments in biophysics, biology and medicine. Some other isotopes, for example ^{43}K and ^{72}Zn were produced in the same way.

References :

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1.) S.A.E.S.-Getters, Technical report No. 77031, (1977) , Milan , Italy.