BACK EXTRACTION SYSTEM OF THE VINCY CYCLOTRON

P. Beličev, Lj. Vukosavljević, S. Ćirković, A. Dobrosavljević, V. Jocić, J. Ristić-Đurović, V. Vujović, Laboratory of Physics, Vinča Institute of Nuclear Sciences, Belgrade, Serbia
I. Kalagin, Flerov Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research, Dubna, Russia

Abstract

The back extraction system of the VINCY Cyclotron, the main part of the TESLA Accelerator Installation, enables extraction of the H^+ ion beams in the energy range of 14-18 MeV at the back side of the machine, and their transport down to the solid target irradiation station in the machine's shielding vault. It is based on the stripping foil technique. These beams will be used for routine production of radionuclides ^{123}I and ^{124}I. We shall present the results of calculations of the dynamics of these beams in the extraction region of the machine, obtained using the VINDY computer code, as well as the results of calculations of their transport down to the irradiation station, obtained using the TRANSPORT computer code. Besides, we shall present the elements of the conceptual design of the system.

INTRODUCTION

Ion beam extraction from the VINCY Cyclotron will be performed by the stripping foil technique. There will be two extraction systems, placed on the two opposite sides of the machine – the front and back extraction systems. The back extraction system will be used to obtain the H^+ beams of the energies of 14-18 MeV, for production of radionuclides with a solid target irradiation station inside the machine's shielding vault. The front extraction system will be used to extract different light beams and low charge state heavy beams, and transport them towards the high energy experimental channels of the TESLA Accelerator Installation [1]. Regarding acceleration of the H^- beam, the roles of the two extraction systems will be complementary. The back extraction system will enable extraction of, e.g., 15 MeV H^+ beam, from the radius of 42 cm, to be used for production of radionuclide ^{123}I. The front extraction system will enable extraction of, e.g., 65 MeV H^+ beam, from the radius of 84 cm, to be used for proton therapy. In the latter case, the stripping foil positioning mechanism of the back extraction system is removed from the acceleration region of the machine.

The H^- beam will be produced by the pVINIS Ion Source, which is a multicusp source, coupled to the (axial) injection transport line of the machine. After being injected in the machine, this beam will be accelerated and extracted from it by the stripping foil technique. An H^- ion that passes through the stripping foil loses both of its electrons and becomes an H^+ ion. In the magnetic field this leads to the change of its direction of rotation, causing its coming out of the machine. The stripping foil is placed such a way to direct the ion properly out of the machine. At the exit of the machine the beam is bent by a magnetic element in order to be directed accurately towards the extraction transport line.

The test beams used in designing the back extraction system were the 14-18 MeV H^+ beams. Calculations of the dynamics of these beams in the extraction region of the machine were performed using the VINDY computer code [2]. The TRANSPORT computer code was used for calculations of the beam transport towards the solid target irradiation station [3].

DESIGN OF THE BACK EXTRACTION SYSTEM

The main constraint in conceptual designing the back extraction system was the limited space on the back side of the machine. The whole system, including the solid target irradiation station, has to be placed in the space determined by the distance between the corresponding flange of the main chamber and the wall of the shielding vault, which is about 2.3 m. Another constraint was the narrow space for placing the stripping foil positioning mechanism of the system, and for accessing the exchange chamber and replacing the stripping foil.

The schemes of the back extraction system are given in Figs. 1 and 2. It consists of the following main parts:

- the stripping foil positioning mechanism (FM1), including the exchange chamber (EXC1);
- the extraction box (EB1) with the wire grid beam position monitor (PM1) and the bending magnet (BM1);
- the extraction transport line, including two focusing (quadrupole) magnets (QM1 and QM2) and a diagnostic box (DB1), with a Faraday cup (FC1) and a rotating wire beam profile monitor (PM2);
- the solid target irradiation station (TS1).

The stripping foil positioning mechanism (FM1) is used for the radial and azimuthal positioning of the stripping foil (F1). Its radial and azimuthal operating ranges are 375-495 mm and 154-165 deg (in the coordinate system of the machine). In addition, it enables exchange of the stripping foil without disturbing the vacuum inside the main chamber. This is achieved by removing the stripping foil from the main chamber to the exchange chamber (EXC1). After closing the gate valve between these two chambers (GV1) and opening the venting valve of the exchange chamber, it will be possible to open the vacuum window of the exchange chamber and replace the stripping foil. The thickness of the stripping foil is 1-2 μm, its dimensions are 20×20 mm^2, and it is made of graphite. The stripping foil is placed at the end of a long supporting rod that can travel through a long bellows,

a perforated plate that reduces the beam current by the factor of 10). The diagnostic box is evacuated by a turbomolecular pump (TP1) of the pumping speed of 210 l/s (see Fig. 2).

The extraction transport line is terminated by the solid target irradiation station (TS1), to be used for production of radionuclides ^{123}I and ^{124}I. It has been developed by our team [4].

Calculations of the dynamics of the test beams in the extraction region were performed using the VINDY computer code [2], with the corresponding measured isochronized magnetic field maps. These calculations enabled us to determine the optimal positions of the stripping foil (F1) and the central trajectories and envelopes of each of the test beams (see Fig. 1). They were performed from the stripping foil down to the entrance plane of the bending magnet (BM1). Figure 3 gives the horizontal and vertical envelopes of the 15 MeV H^+ test beam, obtained from the H^- accelerated beam, in the extraction region.

The TRANSPORT computer code was used to calculate the beam transport from the entrance plane of the bending magnet (BM1) along the extraction transport line, which includes two focusing magnets (QM1 and QM2). The requirement that had to be fulfilled was to obtain the beam spot in the entrance plane of the solid target irradiation station (TS1) of the diameter of 14-18 mm. Figure 4 shows the horizontal and vertical envelopes of the 15 MeV H^+ beam along the line.

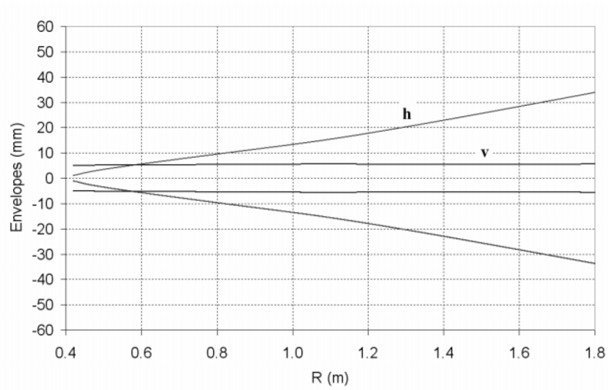

Figure 3: The horizontal (h) and vertical (v) envelopes of the 15 MeV H^+ ion beam as a function of the distance from the center of the VINCY Cyclotron, from the striping foil (F1) to the entrance plane of the bending magnet (BM1).

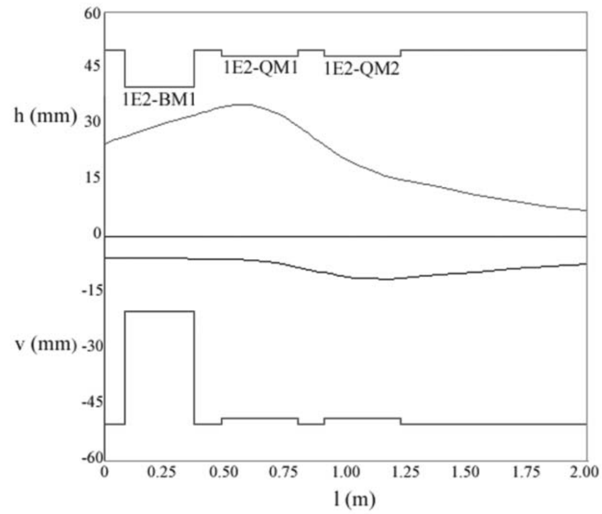

Figure 4: The horizontal (h) and vertical (v) envelopes of the 15 MeV H^+ ion beam along the back extraction system of the VINCY Cyclotron, from the entrance plane of the bending magnet (BM1) to the solid target irradiation station (TS1).

CONCLUSIONS

We have successfully finished conceptual designing the back extraction system. The basic parameters of all its parts have been determined, taking into account the space limitations in the shielding vault and the requirement for successful production of radionuclides with the solid target irradiation station (TS1). The stripping foil positioning mechanism (FM1) enables quick and easy exchange of the stripping foil (F1) without disturbing the vacuum inside the main chamber.

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