H^- ACCELERATION WITH AVF 930 CYCLOTRON

T. Endo, M. Fujita, Y. Miyashita, T. Shinozuka, A. Yamazaki
Cyclotron & Radioisotope Center ,Tohoku University, Sendai, 980-8578, Japan
S. Chiba, S. Kan, A. Matsumura, Y. Omiya, S. Yokokawa
SHI Accelerator Service Ltd., 5-9-11, Kitashinagawa, Shinagawa-ku, 141-8686, Japan
T. Honma
National Institute of Radiological Sciences, 4-9-1,Anagawa,Inage-ku,Chiba, 263-8555, Japan

Abstract

The preparations for H^- acceleration with AVF 930 Cyclotron is in progress. Equipped with a multicusp type ion source and a stripper foil, acceleration tests of H^- ions were started. Until now, the 22µA, 50MeV proton beam is extracted.

INTRODUCTION

As one of the projects at CYRIC(Cyclotron & Radioisotope Center, Tohoku Univ.) 930 AVF cyclotron (K=110MeV), the development of the high intensity proton beam has been planned by the negative hydrogen acceleration for various applications. The goal of this project is to supply 300µA proton beam. That is mainly used as primary beam of high intensity neutron beam which is expected to be use in nuclear physics, material irradiation and study of BNCT cancer therapy. Preparations of instruments and acceleration test are now advancing.

INSTRUMENTS & METHODS

Figure 1 illustrates a layout of the new AVF cyclotron and injection- and extraction-lines. A negative ion source are located on the under ground level, then ions are injected upward into the central acceleration-region through an inflector electrodes. In negative ion acceleration mode, magnet field directions of bending magnets, main coil and the electric field of inflector electrodes are inverted against these in positive ion acceleration mode. Negative hydrogen (H^-) ions are accelerated in the same rotation direction of positive ion acceleration, then their electrons are stripped by the stripper foil, thus converted into H^+; the H^+ ions after the stripping are extracted through the residual magnetic field as shown in the figure.1. The extraction beam line for negative ion acceleration mode consists of one dipole magnet and three quadrupole magnets, then it is connected to the switching magnet at the junction with the beam line for positive acceleration mode.

The multicusp type ion source (BLAKE-V[1]) is used for the negative ion source, it can extract 300µA H^- beam. One third of the H^- beam(100µA) is transported to a faraday cup at the inlet of the cyclotron and one third of the H^- beam at the cyclotron entrance(30µA@main probe) is injected into the central region of cyclotron with the aid of the beam buncher [2].

The position of foil stripper, which is the thin carbon foil of 50µg/cm^2, is able to move its radial position and azimuthal angle in the cyclotron. These two parameters, which determine the energy and starting point of H^+ ions' trajectory, are adjusted to obtain the optimum extraction

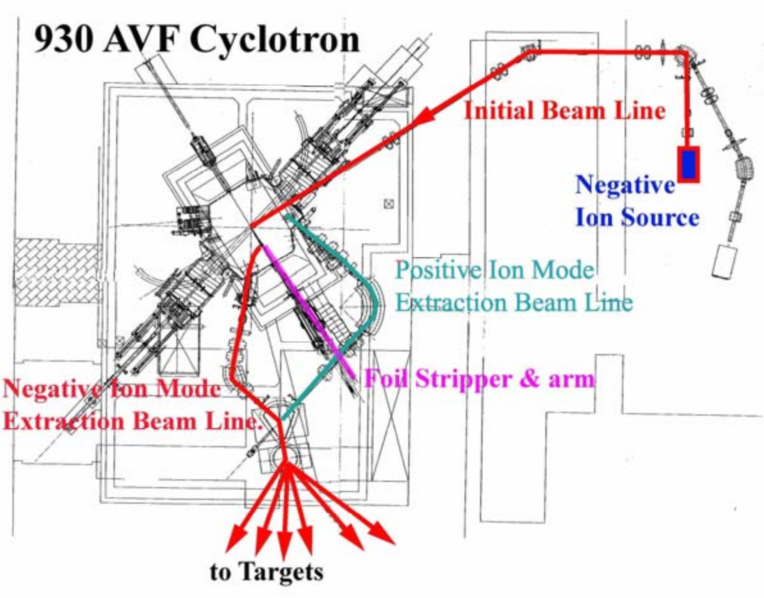

Figure 1: 930 AVF Cyclotron and initial & extraction beam lines.

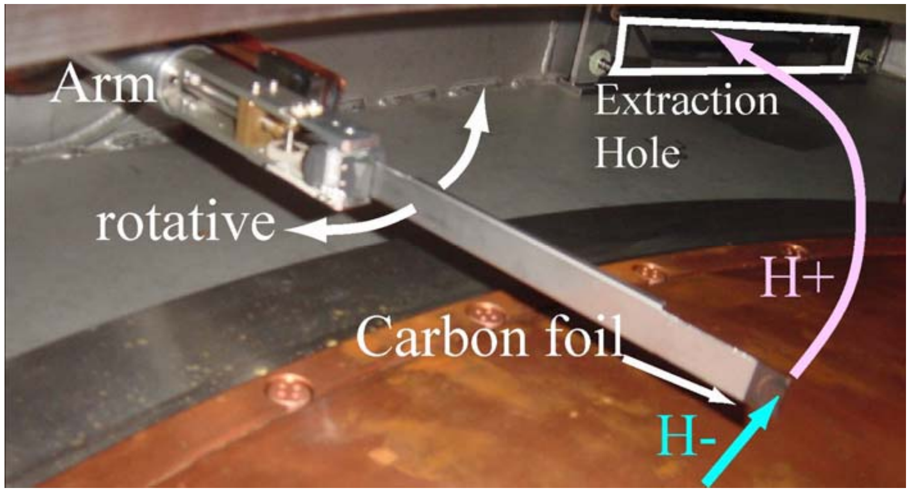

Figure 2: Foil Stripper & arm. A 50μg/cm^2 carbon foil, looks black, put on the tip of the arm.

trajectory.

ACCELERATION TEST & RESULTS

Before H^- acceleration test, the preparations of each components have been tuned for the ion source, test of inverting of magnet fields, attaching the carbon foil to the moving arm and the test of RF operation under the inverted magnetic field of main coil. Figure 3 shows H^- current profile along the radial direction in the acceleration chamber. It shows the qualified acceleration without loss of beam by the gas dissociation or electric stripping[3] of negative ions.

In order to obtain the optimum parameters for the radial position and the azimuthal angle of the stripper foil, beam current is measured by the Faraday cup in front of the first Q-magnet at the extraction beam line. Figure 4 shows the position parameters in which H^+ beam after stripping is extracted from cyclotron.

Since the source position of H^+ ion is definitely set at the foil stripping, the beam transport is easily tuned and, finally, 95% of the beam current of accelerated beam is transported to the switching magnet.

Instruments have already been prepared and acceleration test is now underway for the goal of 50MeV, 300μA proton beam. Presently, we have obtained the 22μA,50MeV proton beam and 95% extraction efficiency by the H^- acceleration. This shows the sufficient feasibility of the high current acceleration and extraction for proton beam with the H^- acceleration.

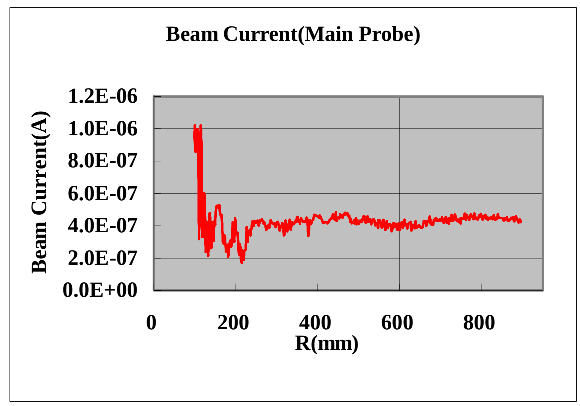

Figure 3: Change of beam current on the R-direction. It is almost flat except for central region.

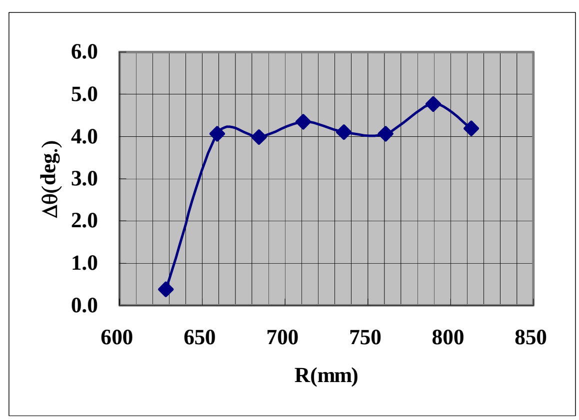

Figure 4: Plot of position of foil stripper when beam current is observed at the entrance of extraction beam line.Δθ is the stripper foil's rotation angle to the arm.

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