SOME R & D FOR THE UPDATE PROJECT OF BEIJING TANDEM LABORATORY

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Abstract

A update project of Beijing Tandem Laboratory was proposed in 1999. The main part of this project is the construction of a 100 MeV, high intensity H- cyclotron. Some R & D for such a cyclotron have been undergoing for two years, e.g. the axial injection line which is able to inject 5.2 mA DC beam to the central region of the machine recently. In this paper, the progress of R&D for the ISOL's target-source system will also be reported.

1 INTRODUCTION

For the RIB study and the high intensity proton beam generation for medical use, the update project of Beijing Tandem Laboratory was proposed by China Institute of Atomic Energy (CIAE) in 1999, which is a modified version of the previous proposal, the Beijing Radioactive Nuclear Beam Facility. In the new proposal, a 100 MeV cyclotron is selected instead of the 70 MeV one so as to get more application by the cyclotron itself. The outline of the update project is shown in figure 1. It includes a 100 MeV cyclotron, an isotope separator on line system, the modification of the existing tandem, an unit of superconducting Linac, the various experimental terminals and isotope production stations. Recently, we plan to start the detail design for the update project soon. The proposed schedule is listed in the table 1. In this paper, several R&D for the update project will be introduced including the ion source and injection line of the 100 MeV cyclotron and the target-source system of isotope separator on line system.

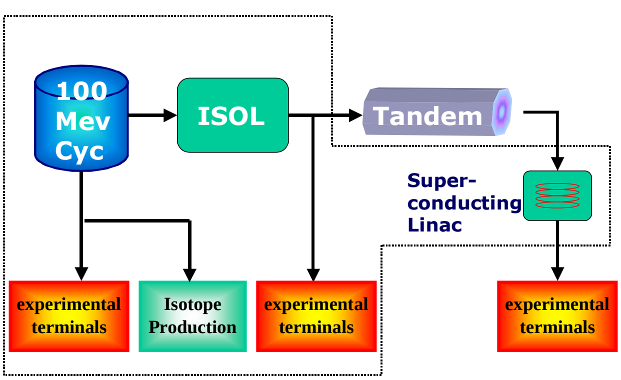

Figure 1: The outline of the update project of Beijing Tandem Laboratory.

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Table 1: Time schedule of the Update Project

Item	2001	2002	2003	2004	2005	2006	2007
Physics Design							
Engineering Design							
Civil Engineering							
Fabrication &Order							
Test & Installation							
Commissioning (Cyclotron)							
Commissioning (ISOL)							
Commissioning (Tandem for RIB)							
Commissioning (Linac)							

2 THE ION SOURCE AND INJECTION LINE OF THE 100 MEV CYCLOTRON

A compact, 100 MeV H- cyclotron is chose for the update project. Only the concept design of the machine is completed currently. The detail dynamics and parts design will be implemented this year, with some collaboration from other institute expected. To get higher beam intensity, a external multi-cusp ion source is used for the cyclotron. The source and axial injection line have be investigated. The test stand of the H- ion source and axial injection line is shown in figure 2.

Figure 2: The test stand of the H- ion source and axial injection line.

2.1 H- ion source

The H- ion source is multi-cusp type. The ten folds of permanent magnets form a optimized cusp field to constrain the plasma which is generated by a filament. The basic principle for H- generation is:

$$H_2 + e^- \rightarrow H_2^* \qquad (1)$$
$$H_2^* + e^- \rightarrow H^- + H^0$$

According to the result of thermodynamics, the electron intensity is as 50 times as that of H- extracted from source at the same temperature. So, the magnet to trap the electron, which is embedded into the extraction electrodes, is playing an important role in this source. The configuration of the filter and the extraction electrodes is also become more important. Figure 3 gives us the structure of the source. 5.2 mA H- beam can be extracted from the source without the Cs injection. The test results with different operation parameters are given in figure 4-6 respectively.

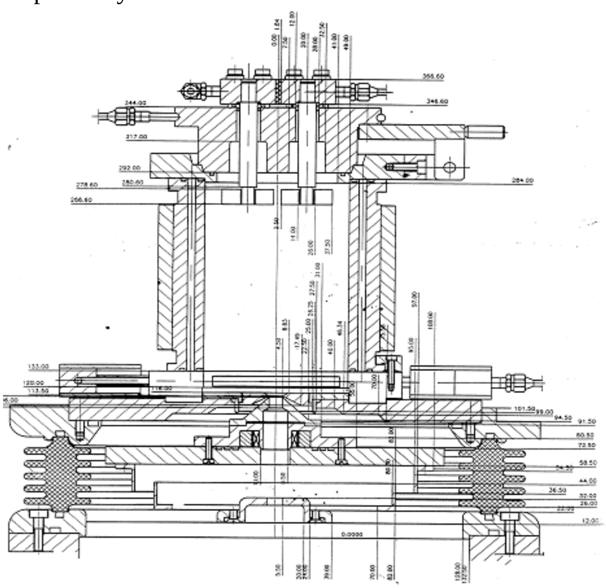


Figure 3: The multi-cusp, H- ion source.

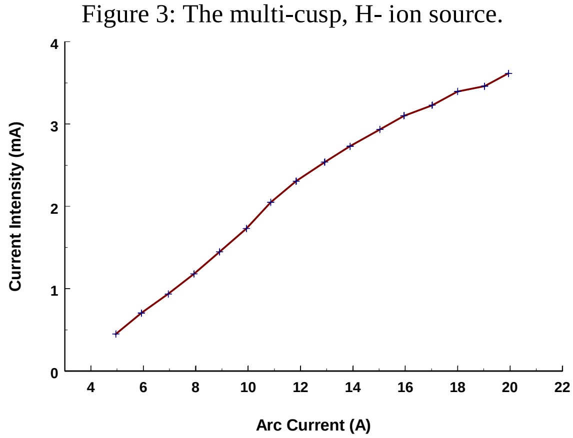


Figure 4: The current intensity versus arc current.

2.2 Axial Injection Line

Based on the rough consideration of cyclotron's dimension, the distance from the extraction hole of multi-

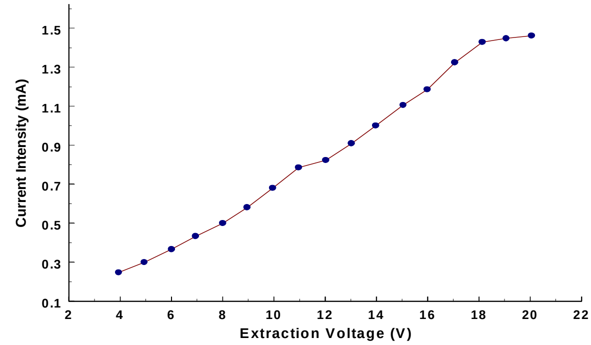


Figure 5: The current intensity versus extraction voltage.

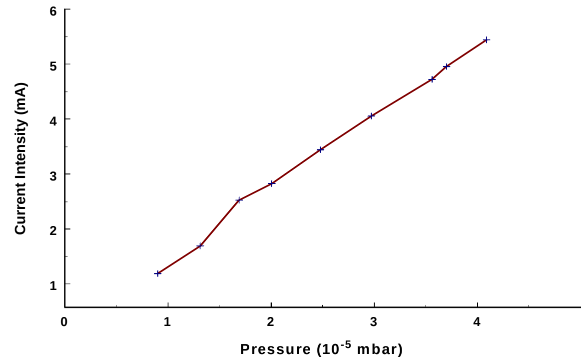


Figure 6: The current intensity versus external pressure.

cusp source to the central region of the machine is 2191 mm. The injection line includes a combine function x-y steering magnet, an Einzell lens, a buncher, a solenoid lens and a inflector. The optics of the line is designed by TRANSPORT/PC and OPTIC-II due to their simple use for match though the space charge effect should not ignored here. We had some results comparison from the different codes, such as TRANSPORT and IGUN. The calculation for results comparison is based on the injection line of the 30 MeV cyclotron, which has been operated for years in CIAE. Here from, we estimated the acceptance and the basic requirements for the elements of the injection line. The envelope of the injection line is drawn simply in figure 7. To significantly short the injection line so as to inject the beam the central region as soon as possible, several elements are designed for the combine function. For example, the x-y steering magnet which field can be rotated in 360° is shown in figure 8. The Faraday cup which can measure the current intensity and emittance at the same time. The solenoid lens is installed in the cyclotron. The main magnet serves as a part of its return yoke. The design field distributions are shown in figure 9.

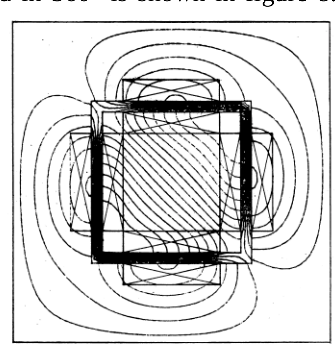


Figure 8: The field distribution of x-y steering magnet.

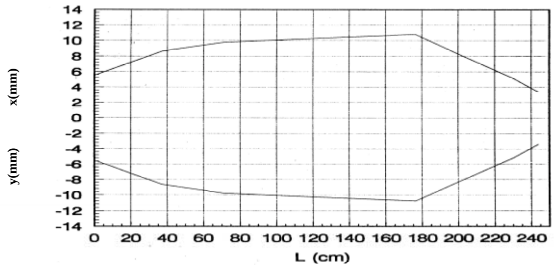
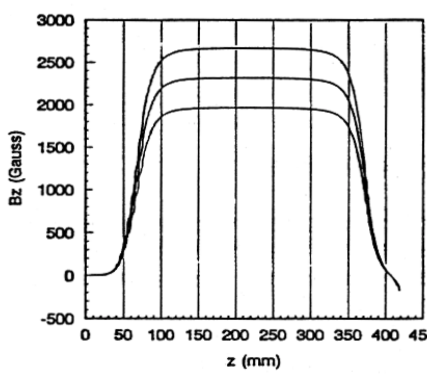


Figure 7: The envelope of the axial injection line.



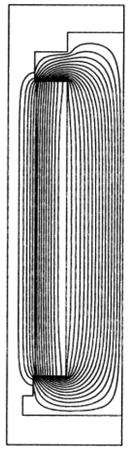


Figure 9: The field distribution of solenoid lens.

3 TARGET-SOURCE SYSTEM

3.1 Simulation of the diffusion, adsorption and effusion processes

The target system design is one of the key problems in the ISOL facility for RIB generation. To check the factors which may affect the efficiency and optimize the design of the system, the diffusion and adsorption processes in the target materials are simulated so as to study the release time of radioactive species from the uniform or Gaussian distribution, cylindrical, spherical or planar target materials operated at the different temperatures based on the idea of using ion implantation at HRIBF for the selection of RIB targets [1]. One of the simulation results is shown in figure 10. The effusion process from the surface of the target material to the ionization chamber of the online ion source is also investigated. The Monte-

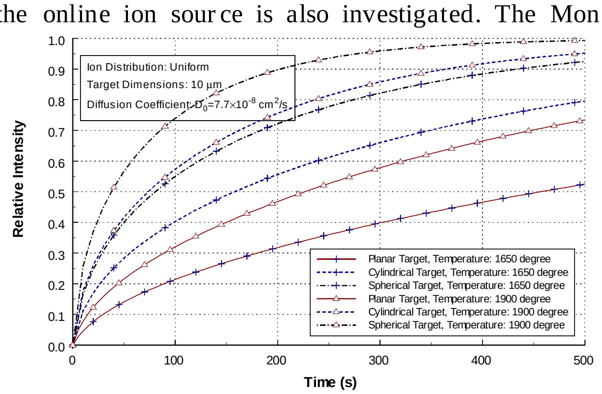


Figure 10: The release time of ^{17}F diffusing from ZrO_2 at different operation temperature.

Carlo techniques are used for the numerical simulation based on the measurement data of surface physics from ZFK, Germany [2]. The experiential formulas and the tables of characteristic effusive-flow times for various particles through tubes of different dimension and materials are extracted from the simulation. One can design the dimension of the effusion tube and select the material for the tube by using the formulas and the tables [3].

3.2 Target-source system

The on line and off line target-source system are investigated in CIAE. One of the off line example is the generation for the beam ^{64}Cu by the cooperation of heavy water research reactor. The on line test system which is shown in figure 11 is being installed on the downstream of the Tandem to generate the keV RIB, such as the ^{62}Zn.

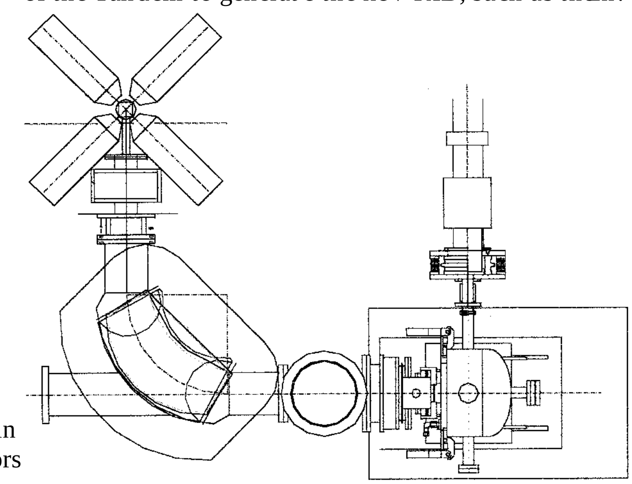


Figure 11: The ISOL test system used for the keV RIB generation.

4 ACKNOWLEDGEMENTS

One of the authors, Tianjue Zhang is very much grateful to Prof. M. Fan and the cyclotron team in CIAE for their advice and support, to Dr. G.D. Alton and the advanced concept group in ORNL for their guidance and cooperation for the simulation of the target-source system.

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