THE PROGRESS OF THE BRISOL FACILITY AT CIAE

B. Tang #, L. Chen ,B. Cui, Q. Huang, W. Jiang, R. Ma, Y. Ma, Z. Peng,
China Institute of Atomic Energy, Beijing,102413, P.R. China

Abstract

Beijing Radioactive Ion-beam Facilities Isotope Separator On-Line (BRISOL), aiming to generate short life radioactive ion beam (RIB) on-line, is being constructed at China Institute of Atomic Energy(CIAE). Up to now, construction of major equipment for BRISOL is completed, including ion source, vacuum system, separator, optical element, and beam diagnostic system, and assembling is underway in laboratory. The on-site installation of all the beam line will be carried out soon. All the major element prototype including surface ion source, quadrupole, hexapole, multipole and beam diagnostic system have been studied off-line on a test-bench for BRISOL. A Li beam was generated and separated . The primary tests show that the ion source and the optical elements work well. The test of charge exchange cell (CEC) is under way. BRISOL will be commissioned next year.

INTRODUCTION

Beijing Radioactive Ion-beam Facility (BRIF) [1], which is shown in Fig.1, is being constructed at China Institute of Atomic Energy (CIAE) and is expected to be commissioned by the end of this year. This project consists of a new 100 MeV& 200 uA compact cyclotron and an ISOL system with a mass resolution of 20000 (BRISOL), which will sever as injection of HI-13 tandem. A new heavy ion superconducting linac booster with the power gain of 2.0 MeV/charge will be built following HI-13 tandem. The progress of construction of BRISOL will be reported in this paper.

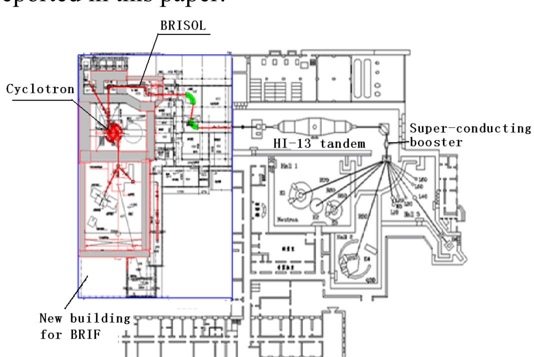

Figure 1: The layout of BRIF.

THE BEAM LAYOUT AND SEPARATOR

The layout of BRISOL is shown in Fig.2. To reach the high mass resolving power of 20000, a bi-energy system with big and small dipoles is used to reduce effect energy dispersion which is too large to get high mass resolving power. The target ion source and first stage separator will be set on the high voltage platform No.1(maximum 300 kV potential to ground), located inside a heavy shielded area. The beam will passes through a 3.5 m thick shielding wall to the high voltage platform No.2, on which the CEC and the first stage mass separator consisting of two 90° magnets which provides a mass resolving of 2000 will be installed. This section is located in a light shielded area. The two platforms will be connected by two 300 kV high voltage conduits, which are used to carry the beam pipe and electrical cables through the shielding wall respectively. Thus the accelerating tube is commercial product purchased from National Electrostatic Company (USA) and delivered to CIAE. The high voltage conduit and high voltage platform will be installed on-site next month and all the elements on the platform will be assembled later.

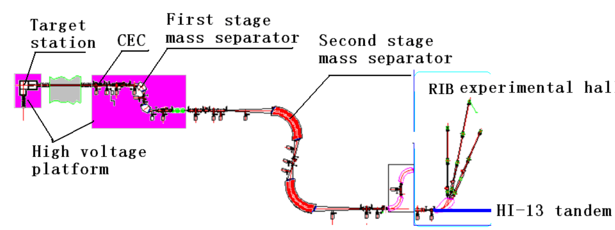

Figure 2: The layout of BRISOL.

The overall mass separation is achieved in the second stage separator, which is placed on ground potential. The separator consists two large dipole magnets with 100° deflect angle and 2.5 m radius, which should finally allow to achieve a mass resolving power of 20000. The radioactive ion beam, with a maximum energy of 300 KeV, will be sent to the beam guidance system consisting two guide dipole magnets and a switch dipole magnet to the tandem or other three RIB experimental terminals.

The construction of the seven magnets for BRISOL were completed and delivered to CIAE in the end of last year. The radius field homogeneity of the analysis magnet is about 3E-4 and can't fulfil the requirement of the high mass resolution especial for the second stage analysis magnet. The mapping for the second stage mass separator is being carried out. A surface coil used by U. Czok [2] will be used in our situation to homogenize the magnetic field from 3e-4 to 5E-5. This technology had also been used on the separator of the BRISOL test-bench. The integral field uniformity of analysis magnet have be improved to 3E-5 from 5E-4 by a pair of surface coil. To correct second-order image aberrations, the entrance and exit field boundaries of magnet are already curved.

#Tangb364@126.com

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Additional, a pair of quadruple surface coil and hexapole surface coil similar as reference [3]), which can make a slightly inhomogeneous magnet homogeneous, will also be equipped on the analysis magnet.

THE TARGET MODULE AND ION SOURCE

The target station, which will be worked in hot area, adopts modulate design, consisting of three modules listed and shown in Fig.3. Entrance module contains the diagnosis, including beam position monitor and scanner, to measure the profile, position and current of the primary proton beam in front of the target. Target module consists of the target, ion source and a proton beam dump. The exit module contains a quadruplole triplet and a pair of steerer to transport and adjust the RIB beam from the ion source, a movable faraday cup are followed to measure the current of radioactive ion beam . A 36 cm thick iron is used to reduce the radioactive level for each module, protecting the vacuum seals, service connections and turbo pump. A large aluminium vacuum tank contains all the three modules. The vacuum, gas and electronic can disconnect automatically when the module is pulled out from vacuum tank remotely. The manufacture and assembly of all the components for target station is finished, and off-line test is underway on the test-bench in laboratory.

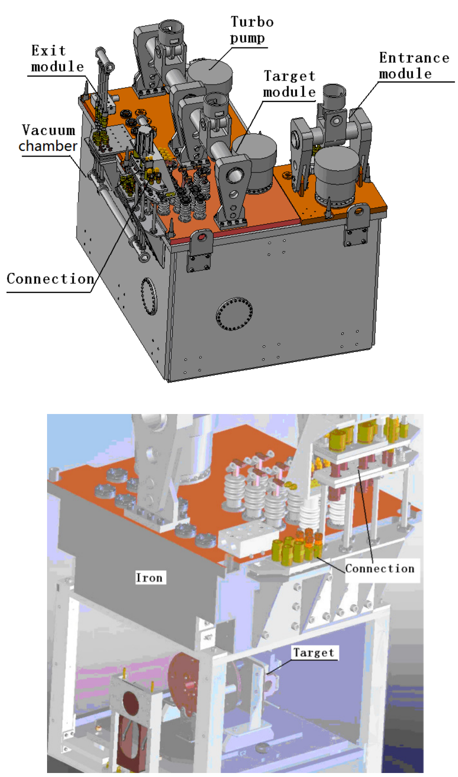

Figure 3: The modulation of target station.

A surface ion source similar as reference [4] is adopted for the first test, shown in Fig.4. The target and cathode are all made of tantalum material and can be resistively heat exceeding 2000 ° C by passing a current. The inner diameter of cathode is 3 mm. A molybdenum disk is placed facing to the cathode to shielding the thermal radiation of cathode. The ion source is support by two insulator block, whereas the maximum voltage of ion source is 50 kV.

The target module and the positive surface ion source have been studied on the test-bench. The primary test show that all the components work well. As off-line experiment, 50 mg Licl was put into the target tube to generate Li^+ beam. The extracted current is easily up to 10 μA at 15 kV extraction voltage when the cathode heating current is 250 A. The emittance, measured by emittance measurement unit(EMU), is 22 π mm.mrad, whereas the normalized emittance is 0.12 π mm.mrad. The mass spectrum of extracted ion beam from target ion source is shown in Fig.5.

A versatile method for target has been explored and a CaO target on porous graphite for online experiment aiming to generate K beam has been prepared.

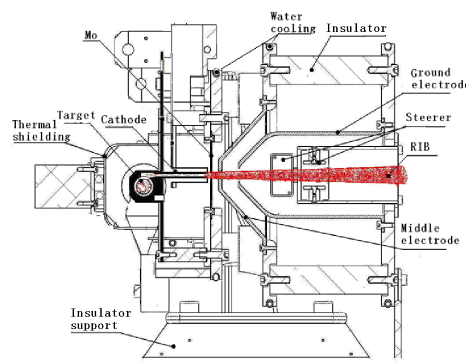

Figure 4: The surface ion source.

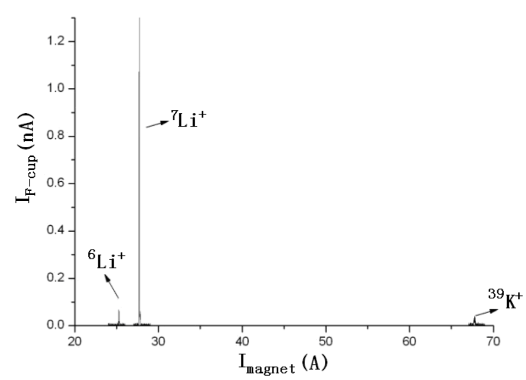

Figure 5: Mass spectrum of extracted ion beam from target ion source.

BEAM DIAGNOSIS

For BRISOL, the beam diagnosis and measurement is a difficult task for the reason of low intensity beams (<10^8 pps). Beam diagnosis should allow both qualitative and quantitative measurement, in order to perform an efficient beam tuning and transport. Different types of diagnostic element including faraday cup, beam profile monitor

(BPM) [5], emittance measurement unit and scanner are adopted on BRISOL beam line to monitor the low energy beam, as shown in Fig.6. All these diagnostic elements are integrated in a vacuum chamber, as shown in Fig.7. Beam profile monitor is based on a CsI (T1) scintillating plate, that is when the beam bombard on the CsI (T1) scintillator, the CCD camera can acquire the image of beam spot. The EMU developed by Allison[6] is a scanner that measures the trajectory angle distribution with an electric sweep while a mechanical scan probes the particle position distribution. The current measurement is carried out by a current amplifier whose minimum measured value is up to 0.1 pA. All these diagnostic elements have been tested offline.

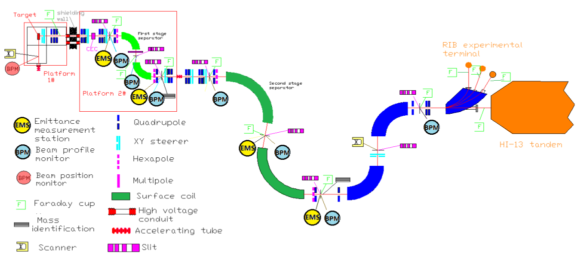

Figure 6: The layout of the diagnosis element.

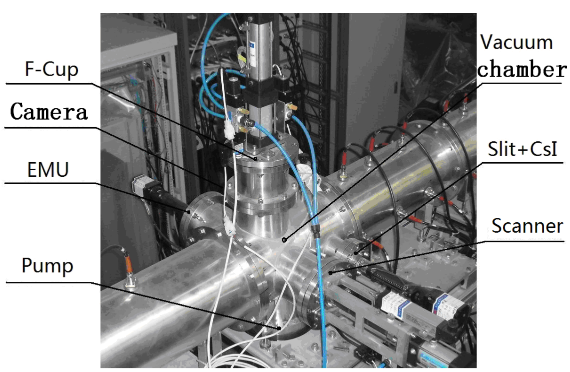

Figure 7: Beam diagnostics unit.

A scanner and a beam position monitor[7] is assembled in the entrance modulate to monitor the primary proton beam. Two pairs of semicircle 0.025 mm thick aluminium segment with a 18 mm*18 mm hole are used to monitor the beam position by measuring the secondary electron. The beam position monitor is also tested using 25 MeV proton beam from tandem, and work well. The prototype tested on HI-13 tandem beam line is shown in Fig.8.

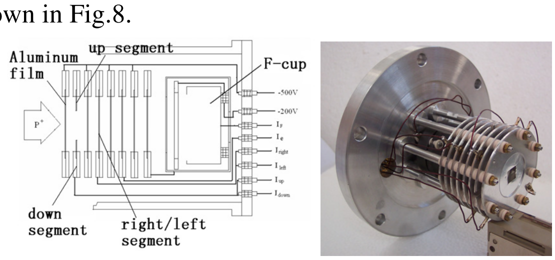

Figure 8: Beam position monitor tested on HI-13 tandem beam line.

OTHERS

The design and manufacture for vacuum system has been finished, three radiation-hard and low activation turbo pumps for target station is special designed and manufactured. A big aluminium vacuum chamber is used for target station in order to reduce the material activation.

The manufacture of electrostatic quadruples and electrostatic steers is finished and their assembly is underway.

All the power supplies including 300 kV high voltage power supply, power supply for magnets, lens and steers have been delivered to CIAE.

The computer control system is in progress.

Also the auxiliary equipment such as exhaust collection system and cooling system for radioactive ion source has been manufactured.

CONCLUSION

The construction of BRISOL is in progress as schedule. The manufacture of most system components have been finished and their assembly is underway. The target ion source has been installed and its commissioning is been carried out on a test-bench in laboratory. A Li beam has been produced from the target ion source. 7 magnets of the system have been delivered to CIAE and magnetic field mapping is carried out. The electrostatic quadruple and steer, beam diagnostics units have been manufactured and its assembling is underway in laboratory. The beam line will be installed on-site soon, whereas BRISOL will be commissioned next year .

ACKNOWLEDGMENT

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