

ION SOURCES FOR THE FIRST STAGE OF THE DRIBS PROJECT

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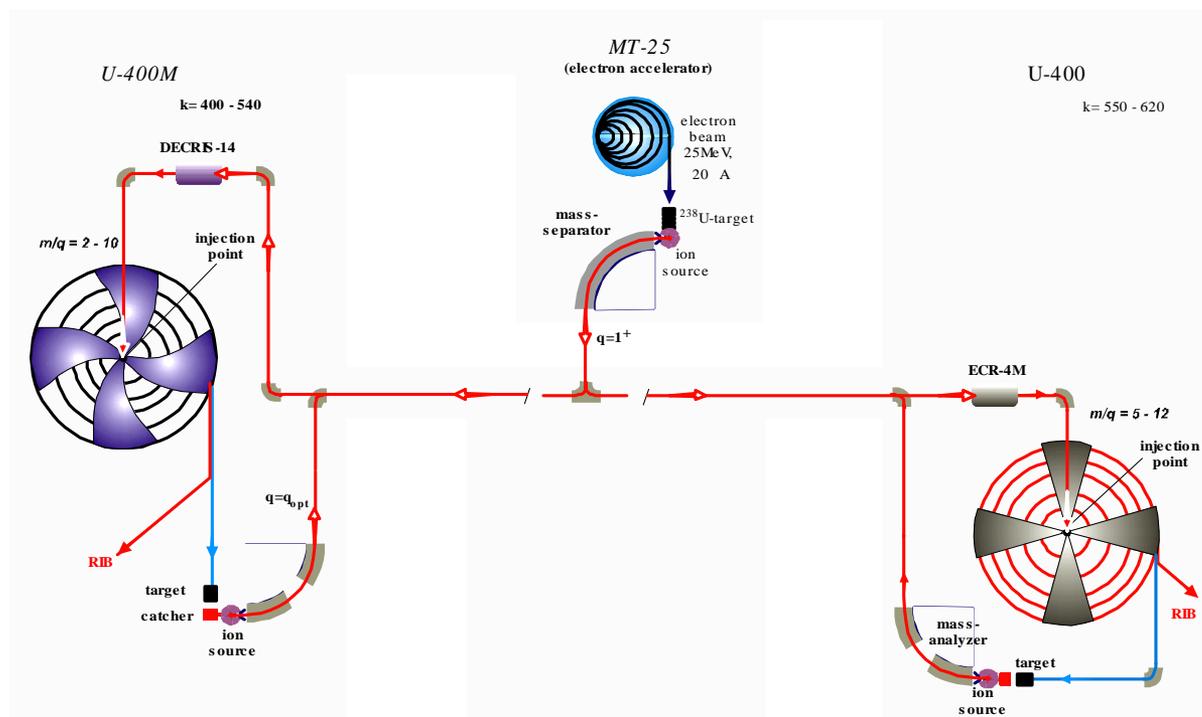


Figure 1. The scheme of the location of the MT-25 microtron and the U-400 and U-400 M cyclotrons connected by a transport line. Different variants of radioactive beam injection into the cyclotrons are shown.

Abstract

In accordance with the plan of development of JINR the production of exotic nucleus beams is one of the main scientific research lines. DRIBs (Dubna Radioactive Ion Beams) project suggests the use of two accelerator setups: the primary beam accelerator inducing the reaction at a production target, and the accelerator of radioactive nuclei transported into its ion source or directly into the center of an accelerator chamber. These two functions can be performed by two acting FLNR accelerators of the U-400 class.

The first stage of the project assumes the direct acceleration of radioactive light ions (such as ${}^6\text{He}$, ${}^8\text{He}$, ${}^9\text{Li}$, ${}^{11}\text{Be}$) at the U-400 cyclotron. Two versions of the 2.45 GHz ECR ion source for the production of single charge state ions of secondary atoms were designed. The design aspects and results of the first tests of these ion sources are presented in this paper.

1 INTRODUCTION

The use of secondary beams of radioactive nuclei considerably widens the possibilities to investigate the properties of atomic nuclei and nuclear reactions [1]. The experiments with radioactive nuclear beams will be aimed

at obtaining new information concerning the following three main issues of nuclear physics:

- investigation of the properties of atomic nuclei far from the stability line, including nuclei at the proton and neutron drip-lines,
- study of the peculiarities of the dynamics of nuclear reactions induced by proton- and neutron-rich nuclei,
- synthesis and study of the properties of new elements and isotopes.

The conceptual scheme of the project is shown in Figure 1. DRIBs (Dubna Radioactive Ion Beams) project suggests the use of two accelerator setups: the primary beam accelerator inducing the reaction at a production target, and the accelerator of radioactive nuclei transported into its ion source or directly into the center of an accelerator chamber. These two functions can be performed by two acting FLNR accelerators of the U-400 class.

The other idea is to produce a beam of neutron-rich isotopes being formed in the fission of uranium and thorium nuclei. At the energy of gamma-quanta in the range of the ${}^{238}\text{U}$ giant resonance (13.5-14 MeV), the fission cross section is high enough. The advantage of this variant consists in the use of a compact electron

accelerator (Microtron MT-25) and one of the U-400 accelerators.

Realization of the RIB project assumes some modernization of the accelerators and ion sources, creation of a new beam channels. For production of fission fragment beams it is necessary to create several types of ion sources, operating with elements in gaseous states (isotopes of Kr and Xe), alkaline elements (Rb and Cs isotopes), as well as elements of the Sn, Sb and Te group.

Different types of ion sources were used in each individual case for the production of single charge ion beams of different atoms. The development of ECR-sources with comparatively low microwave frequency ($f=2.45$ GHz) lately opens new possibilities for beams of single charge state ions of light elements [2]. The first stage of the project assumes the direct acceleration of radioactive light ions (such as ${}^6\text{He}$, ${}^8\text{He}$, ${}^9\text{Li}$, ${}^{11}\text{Be}$) at the U-400 cyclotron. Here we present some design aspects of two versions of the 2.45 GHz ECR ion source and results of the preliminary test.

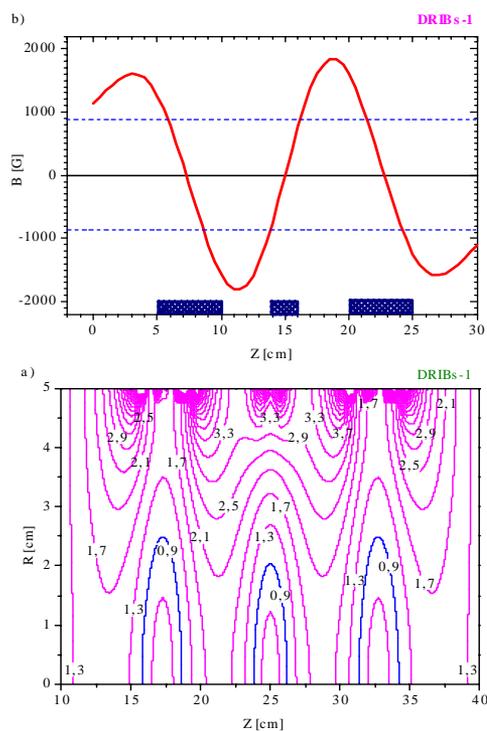


Figure 2. Magnetic field contour plot (a) and axial magnetic field distribution (b) for the first version of the ECR ion source.

2 DESCRIPTION OF THE ION SOURCE

The 2.45 GHz ion source is dedicated for the production of singly charged radioactive ion beams. For this reason the source parameters such as efficiency, reliability and low cost are very important. Two versions

of the magnetic structure on the base of permanent magnet rings with different magnetization were designed.

The static magnetic field required for the ECR is 875 G. The first magnetic configuration is made with three radially magnetised permanent magnet rings. That allows to create pseudo-closed resonance surface, as it shown in Figure 2a. The axial magnetic field distribution is shown in Figure 2b.

The second magnetic configuration is made with two permanent magnet rings. In this case the easy axis of each magnet is inclined to the axis of the magnetic system. The advantage of this configuration is the availability of enough room between two magnets to install desired radial ports. These ports can be used for both the UHF feeding system and radioactive atoms inlet system.

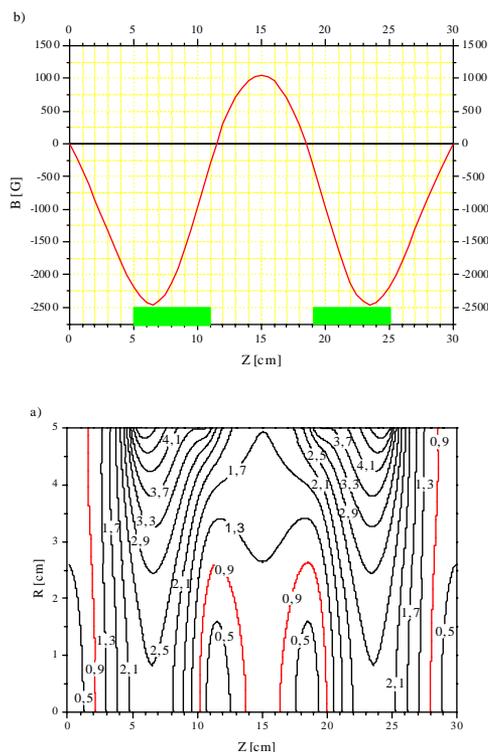


Figure 3. Magnetic field contour plot (a) and axial magnetic field distribution (b) for the second version of the ECR ion source.

The schematic structure of the ion source with the first version of the magnetic structure is shown in Figure 4. The choice of 2.45 GHz operational frequency (wave length 12.2 cm) has several consequences for the layout of the ion source. The plasma chamber has to be relatively large to ensure of efficient propagation of microwaves into the plasma chamber. The plasma chamber diameter of 90 mm was chosen. The length of the plasma chamber corresponds to a single TE_{111} mode cavity. To protect the permanent magnet rings from demagnetisation by high temperature, a water-cooled plasma chamber has been constructed. A 2.45 GHz microwave is injected into the plasma chamber through

the coaxial vacuum transition ended by a rod. The magnetron generator delivering up to 300 W of microwave power is installed at the high voltage platform. Matching of the microwave power to the plasma is optimised by the special tuner.

The extraction system consists of two electrodes. The plasma electrode hole diameter is 5 mm. It is located in a 1700 G magnetic field.

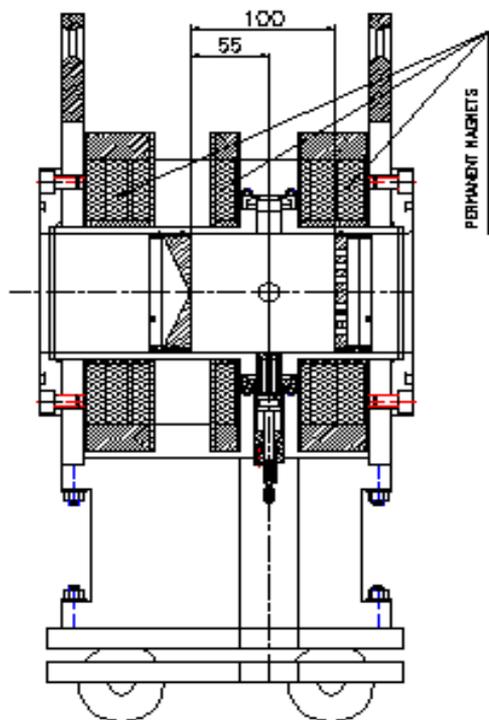


Figure 4. Design drawing of the 2.45 GHz ECR ion source.

3 FIRST RESULTS

Since the production of ${}^6\text{He}$ and ${}^8\text{He}$ ion beams is our goal in the very near future, the preliminary tests of the source with the first version of the magnetic configuration have been run with He. It has to be pointed that the ion source was optimised to produce the maximum ion current only. The source has been tuned with different position of the plasma electrode. The pressure inside the source fell within broad range between 10^{-3} and 5×10^{-6} Torr. Pumping of the plasma chamber was provided through the extraction hole (diameter 5 mm). The typical extraction voltage was 18 kV.

The pressure dependence of the He^{1+} extracted beam with different levels of microwave power is shown in Figure 5. The ion source could produce more than 200 μA of single charged He when the injected microwave power did not exceed 11 W. About of 1.4 mA of He^{1+} was extracted from the source with the microwave power of 80 W.

It is well known, that a 2.45 GHz ECR ion source would create a lower ionisation factor and lower electron

temperature, thus suppressing the production of the high charge state ions and enhancing single charge state ions [3]. Figure 6 shows the typical He spectrum when the source was tuned to the maximum He^{1+} ion current.

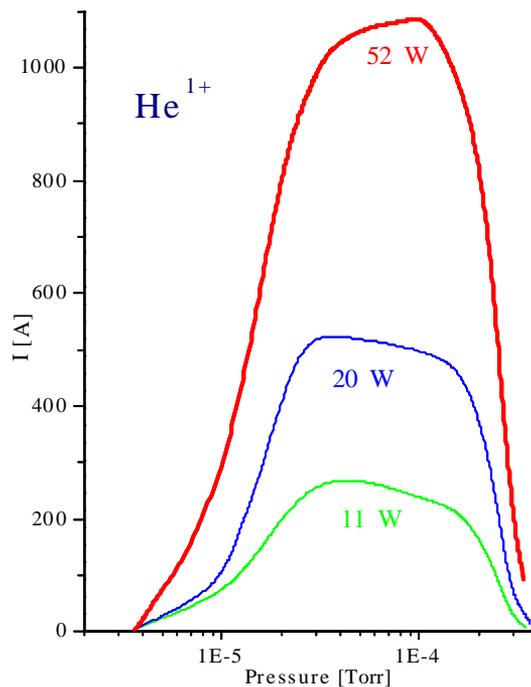


Figure 5. He^{1+} ion current vs pressure.

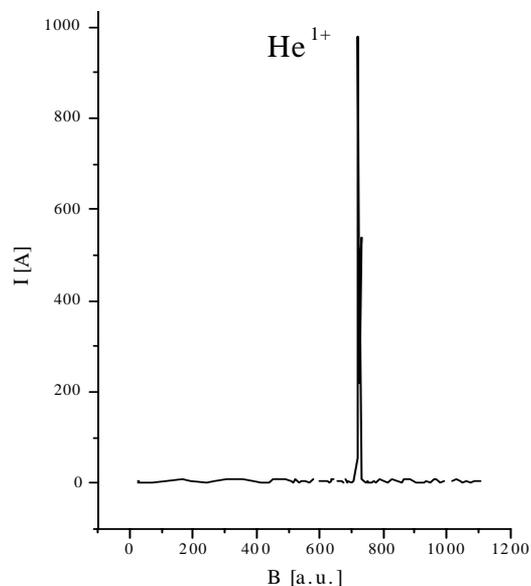


Figure 6. He spectrum. Extraction voltage is 18 kV.

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