DESIGN AND CONSTRUCTION OF THE NEW ION SOURCE DECRIS–4

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Abstract

The new ECR ion source DECRIS-4 is now under construction. The source will be used as an injector of heavy multiply charged ions for the U-400 cyclotron as well as a "charge breeder" (the "$1^+ \rightarrow n^+$" method) for the second phase of the DRIBs project. The main feature of the ion source design is the creation of the extended resonance zone in a comparatively compact ECRIS. For this purpose the axial magnetic field is formed with a flat minimum. In this case the superposition of the axial magnetic field and the radial field of the permanent magnet hexapole, made from NdFeB, allows one to create a larger resonance volume. For the plasma heating a microwave frequency of 14 GHz will be used. The design of the ion source and its magnetic structure are presented. Some features and prospects of the source application are discussed.

INTRODUCTION

The DRIBs (**D**ubna **R**adioactive **I**on **B**eams) project started in accordance with the plan of the FLNR (JINR) development few years ago. The idea of using the secondary radioactive nuclei beams strongly extends the possibilities for the investigation of properties of atomic nuclei and nuclear reactions. The production of exotic nucleus beams is one of the main scientific lines in FLNR.

In the second stage of the DRIBs project [1, 2], it is planned to use a primary electron beam from the Microtron MT-25 for the production of radioactive neutron–rich nuclei (^{238}U photo fission fragments). The beam of single–charged radioactive ions can be turned to the low-energy laboratory or post–accelerated in the cyclotron U–400, which can accelerate ions with A/Z from 6 to 12. For this reason the development of a new ECR ion source there was started with the aim of solving two problems:

a) To design a new ion source [3], which can be used as a "charge breeder" for the second phase of DRIBs project. In this case the single–charged ions will be transported into the ECR ion source and then extracted with the n^+ charged state required for the acceleration.

b) To improve the efficiency of the ^{48}Ca ion beam production, which has been the most frequently accelerated beam (more than 70 % of the operation time) [4] at the U–400 cyclotron within the past few years.

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In this article, we present the design parameters and status of the development of the new ion source DECRIS–4.

DESIGN OF THE ION SOURCE

The design of the magnetic structure of the source was based on the idea of the so-called "magnetic plateau" in the center of the source suggested by Alton and Smithe [5] and successfully realized by the Munster University team [6]. A cross-sectional view of the ion source DECRIS–4 is shown in Fig. 1. The main parameters are collected in Table 1.

Table 1: The main parameters of DECRIS–4.

Main parameters	
UHF frequency	14 GHz
B_{inj}	1.25 T
B_{ext}	1.25 T
L_{mirror}	29 cm
Max. coil current	1000 A
Water cooling $\triangle$P	12 bar
Plasma chamber internal diameter	74 mm
Hexapole field on the wall of plasma chamber	>1.0 T
Max. extraction voltage	30 kV

The axial magnetic field is formed by 3 independent solenoids enclosed in separated iron yokes. An enlarged resonance zone can be created with the help of the middle coil and two movable soft iron rings (in Figure 1 they are shown by hatching). The position of the rings depends on the coil current and will be assigned experimentally. The maximal magnetic field at the axis is about 1.25 T on both sides which provides a mirror ratio about 2.5 (see in fig-

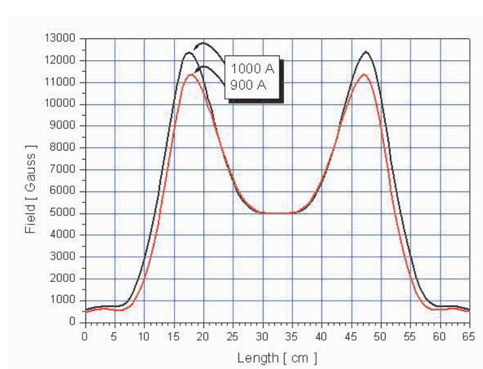

Figure 2: Axial magnetic field distribution.

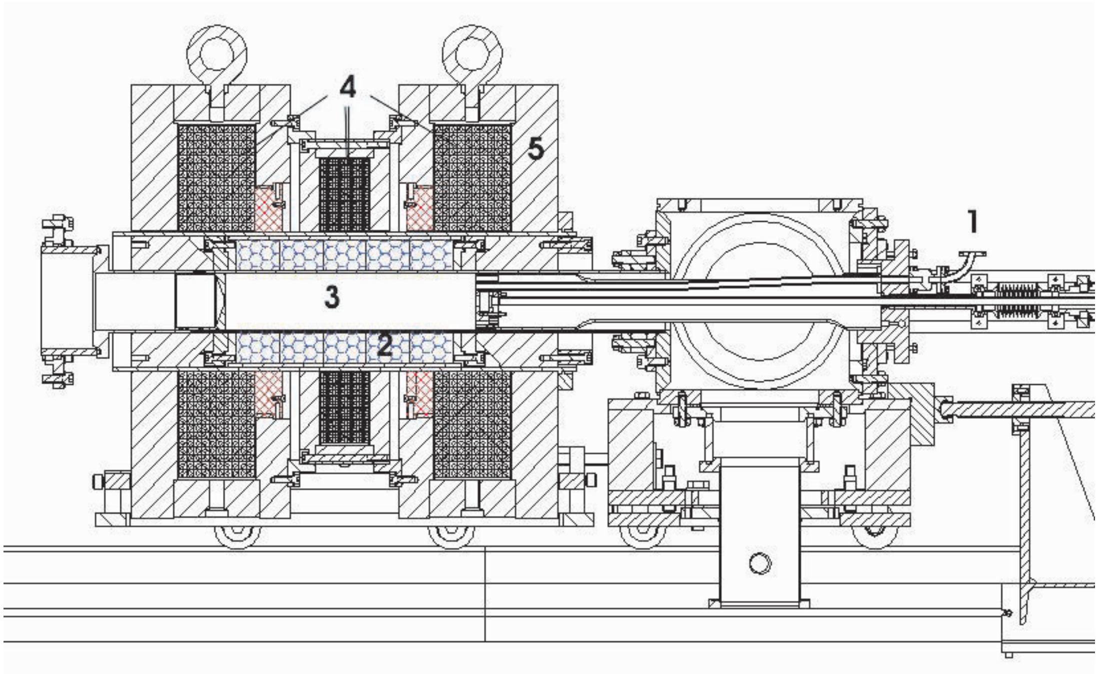

Figure 1: Magnetic structure of the ion source DECRIS–4. 1: UHF input. 2: Hexapole. 3: Plasma chamber. 4: Three independent coils. 5: Iron yoke.

ure 2). The hexapole for the radial confinement has a Halbach structure. It consists of 24 permanent magnet identical sectors. The outer diameter is 160 mm, the inner one is 80 mm. The desired magnetic field on the plasma chamber wall is about of 1 T. The superposition of the coils and hexapole magnetic fields (three-dimensional view) is shown in Fig. 3, and the magnetic field contour map is shown in Fig. 4. In figure it is easy to see the enlarged resonance volume marked with dark colour. The whole magnet structure is moveable along the axis with respect to the plasma chamber to optimize the plasma electrode position during the source operation.

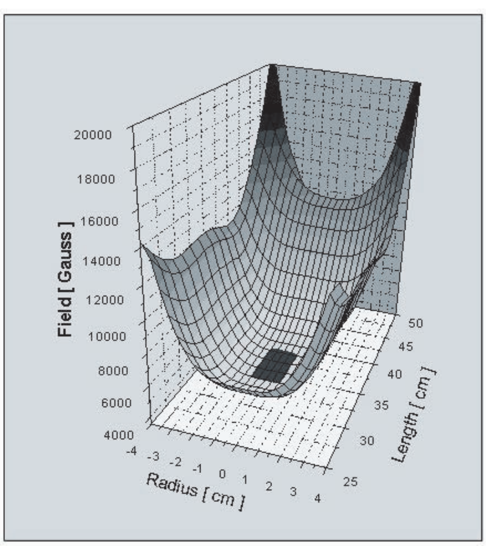

Figure 3: Three–dimensional magnetic field distribution. The dark area in the center corresponds to the enlarged resonance zone.

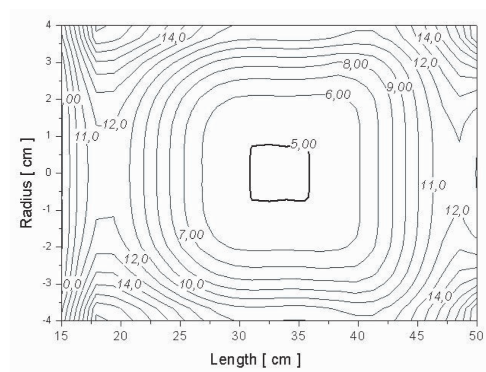

Figure 4: Schematic view of surfaces of magnetic equipotentials. The thick line in the center shows the enlarged resonance surface.

For the ECR heating we can use a single 14 GHz and 2 kW klystron or, in the future, a few frequencies produced by independent oscillators which are mixed and amplified by a TWT.

As compared with the previous versions of DECRIS, the new ion source has some more other innovations, such as a bigger size plasma chamber, a movable bias electrode for precise cavity tuning, UHF power is fed by the standard waveguide instead of coaxial feeding and so on. The injection side of the source has more room for the installation of a new high temperature oven with temperature control and a bigger size crucible. This allows us to increase the efficiency and time of nonstop operation during the ^{48}Ca ion beam production.

STATUS AND RESULTS OF MAGNETIC MEASUREMENTS

The mechanical draft drawing of the ion source was ended in June of this year. The parts of iron yoke, the main solenoid coils and the middle one are under construction now. The final assembly of the DECRIS–4 and preliminary tests is assumed at the end of this year.

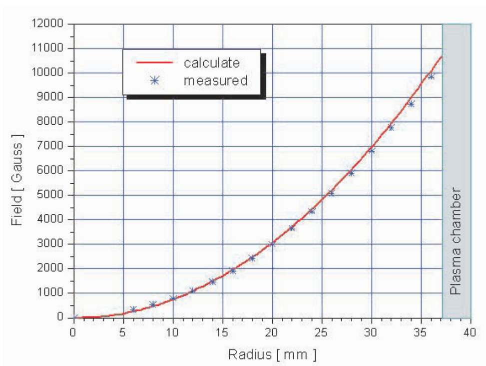

Figure 5: Comparison calculated and measured radial magnetic field of the hexapole.

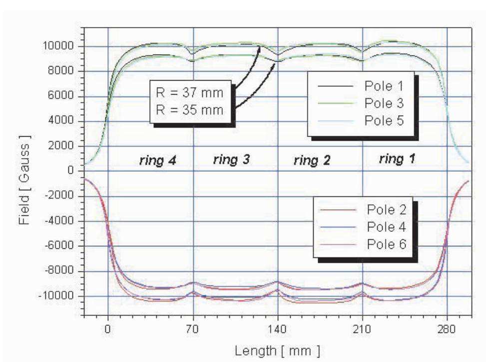

Figure 6: Distribution of radial magnetic field of the hexapole along an axis at different radius.

Hexapol magnet was completed in the beginning of September. It consists of 4 rings (24 pieces Halbach structure) and its length is 28 cm. Hexapole is made from NdFeB magnets. Some results of the hexapole magnetic field measurements and comparison with the design parameters are presented in Fig. 5 and Fig. 6. As it‘s shown in Fig. 5, calculated and measured values of radial magnetic field are almost identical and the value of magnetic field on the radius 37 mm, which correspond the wall of plasma chamber, is not smaller as desired on whole length of hexapole (see Fig. 6).

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