Design of Magnet System for ECR Ion Source

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Abstract

Investigation and optimization results of the magnetic system for the ECR source of multicharged ions at 14 GHz microwave frequency , corresponding to the 0.5 T resonance magnetic field are presented in this paper.

I. INTRODUCTION

At present, in ion beam physics and technology a considerable progress is seen. It is directly attributed to the development and construction of ECR sources with the operational principle based on ions extraction from hot electron plasma heated by electron-cyclotron resonance to the temperature necessary for the generation of multicharged ions of the working substance.

For stable plasma confinement a magnetic field of "minimum $\vec{B}$" configuration, increasing to all sides from the region occupied by the plasma, is used. Such field configuration in the ion source results from the superposition of the fields produced by coaxial coils and a multipole structure. In this case the surface of ECR heating, determined by the resonance magnetic field should be closed and does not cross the walls of the main ionization chamber.

Usually, a hexapole, made out of permanent *Sm Co* or *Nd Fe B* magnets, is employed as a multipole structure. The hexapole produces magnetic field increasing in radial direction. A coil system is a simple mirror trap with the mirror ratio of 1.5–2. and provides field increase in the axial direction.

Lack of the axial symmetry in the magnet system necessitiles the 3-dimensional calculations of the hexapole field, in particular, the identification of the character of edge fields distribution because of probable appearance of the spurious resonances in the area of the ion beam extraction and RF power input.

II. MAGNETIC STRUCTURE

ECR source magnet design was developed to meet the specification requirements and minimize the electrical power in solenoidal coils and the volume of the permanent magnet material. The longitudinal cross-section of the magnetic system is shown in Figure 1.

Main design parameters of the magnet system are listed in the following table:

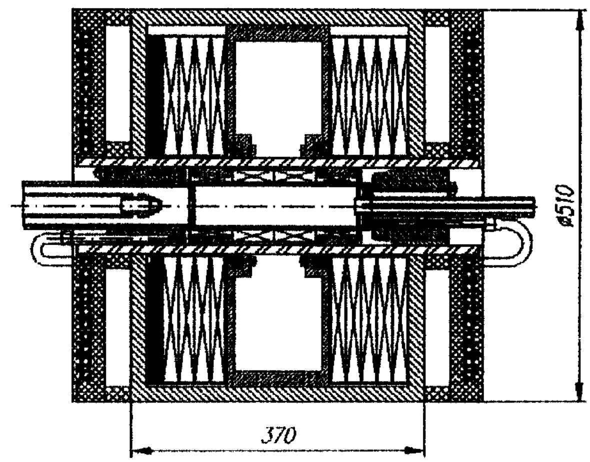

Figure 1: The longitudinal cross-section of the magnetic system.

Total number of turn	320	
Current	370	A
Conductor current density	7.42	A/mm^2
Total Resistance at 20°	0.108	Ω
Total Voltage	43	V
Pressure drop	0.5	mPa
Weight of copper	60	kg

The system consists of two solenoidal coils, a ferromagnetic yoke and poles and a permanent magnet hexapole. The coils utilize a water-cooled square copper conductor of 8.5mm x 8.5mm with a cooling bore of 5.3 mm. The conductor is wrapped with insulation tape and vacuum impregnation is used. The longitudinal magnetic field system provides the mirror ratio of $R_0 = 1.5$–1.65 inside the ionization source chamber. The electrical power of the system is 15.6 kW.

The hexapole construction was optimized [1].

The hexapole is composed of 4 rings of equal length. Each of them consists of the $N = 24$ segments made of *Nd Fe B* magnets with the residual induction of $B_0 =$ 10.5 kGs. The number of segments $N = 18$ seems to be optimal in technological aspect. The permanent magnet ring magnetization vector $\vec{M}$ lies in the plane perpendicular to the longitudinal axis. The outer diameter of the extreme rings can be reduced proceeding from the plasma

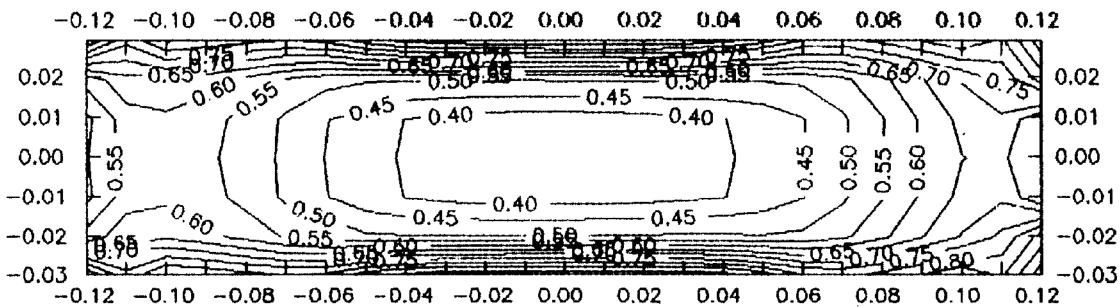

Figure 2: The longitudinal field profile of an ECR source.

stability conditions.

Figures 2,3,4,5 show the total magnetic field distribution at the different cross-sections of the ionization chamber. These figures make it possible to display the surface of ECR heating location corresponding the field level of B=0.5 T.

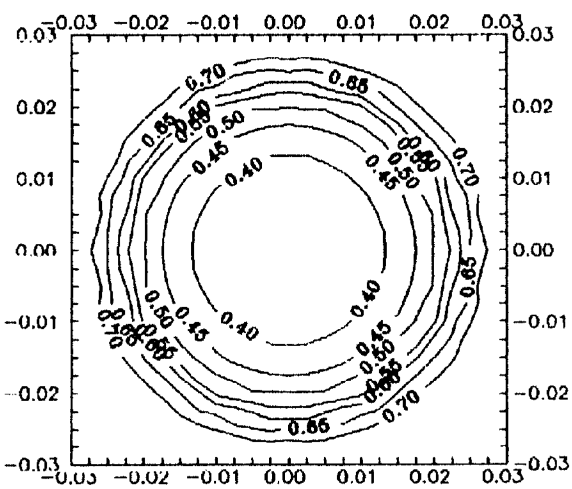

Figure 3: The transversal field profile of an ECR source (a middle cross-section).

III. CONCLUSION

The magnetic system design is the base of the compact ECR source of multicharged ions.

IV. REFERENCES

[1] A. A. Vasiliev, V. P. Kukhtin, E. A. Lamzin, Yu. P. Severgin, S. E. Sytchevsky "Choice of Magnetic structure for ECR Ion Source" presented at *IEEE Particle Accel. Conf.* 1993, pp.3205 3206.

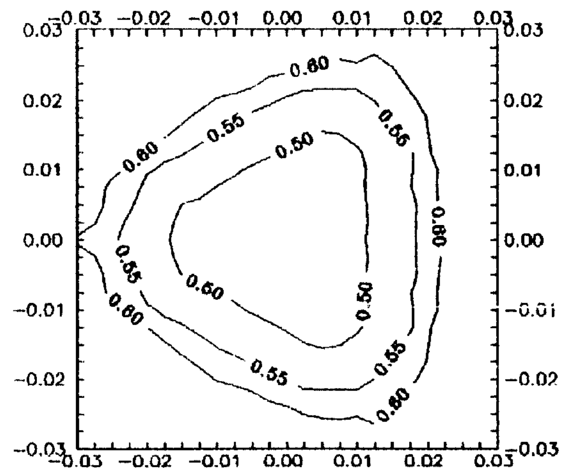

Figure 4: The transversal field profile of an ECR source (a left cross-section).

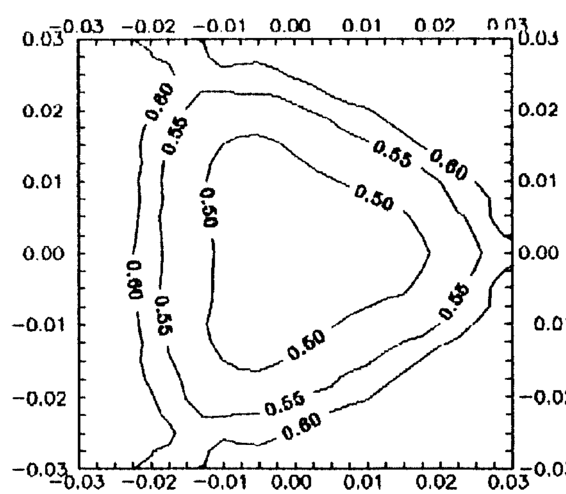

Figure 5: The transversal field profile of an ECR source (a right cross-section).