PRODUCTION OF INTENSE BEAMS OF IRON IONS FROM ECR ION SOURCES BY MIVOC METHOD AT THE CYCLOTRON DC-60

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Abstract

The article describes the experiments carried out in 2015 at the accelerator complex DC-60 of Astana branch of the INP (Alma-Ata, Kazakhstan Republic), to develop methods for production of intense beams of multi charged ions of iron with the use of volatile compounds (Metal Ions from Volatile Compounds) – MIVOC [1]. As a result of performed work for the first time at DC-60 cyclotron a beam of iron ions was obtained, acceleration mode of $^{56}Fe^{10+}$ ions to the energy of 1.75 MeV/n was optimized

PRODUCTION OF IONS $^{56}Fe^{10+}$ USING VOLATILE COMPOUNDS MIVOC

For production of the iron ions from the ECR ion source DECRIS-3 [2] the ferrocene compound $Fe(C_5H_5)_2$ was used as a working substance. The working substance was put into the metallic container, which was connected to the ECR source via piezoelectric leak valve SNA-2.

The smoothly opening of the piezoelectric leak valve allows the injection of molecular flow of substance into the source. If the substance flow is not sufficient for stable source operation, helium can be used as a support gas. After optimization of the ECR ion source settings the following results were obtained: 50 eμa of Fe^{9+} ions, and 15.6 eμa of Fe^{10+} ions.

Figure 1 shows charge state distribution of iron ion beam, obtained after the bending magnet of the axial injection system of the DC-60 cyclotron, source settings being optimized for the production of Fe^{10+}.

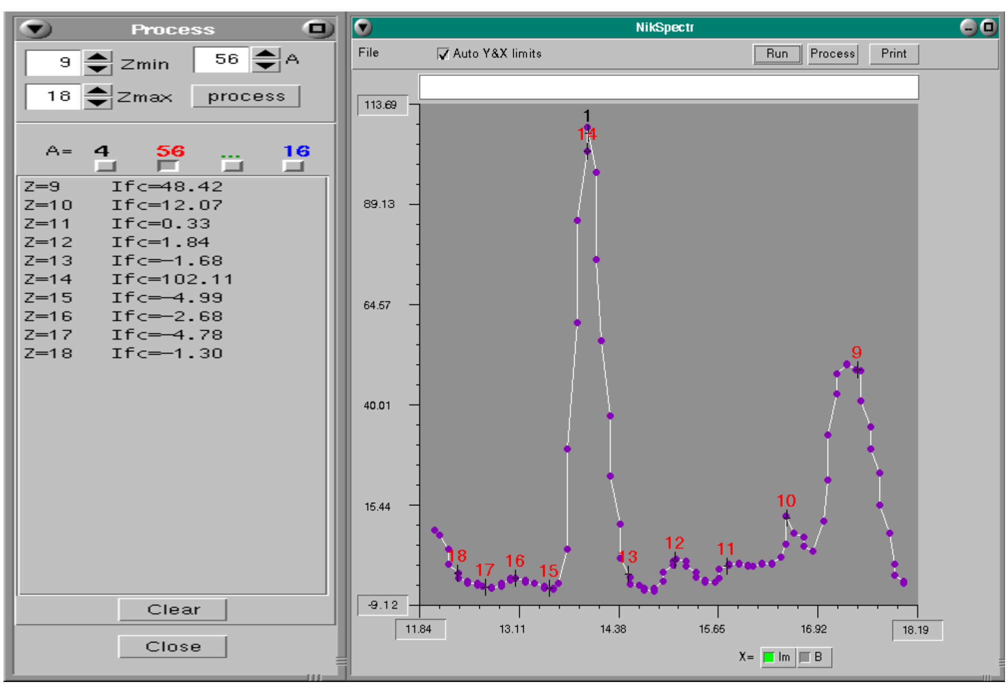

Figure 1: Charge spectrum of iron ions produced by the DECRIS-3 ion source. The position of Fe^{14+} ions coincides with the position of C^{3+} ions.

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ACCELERATION OF $^{56}Fe^{10+}$ IONS

For the first time in Kazakhstan at the accelerator complex DC-60 the accelerated beam of $^{56}Fe^{10+}$ ions with the energy of 1.75 MeV/nucleon was produced. Calculated parameters of the acceleration mode are given in table 1.

After optimization of the axial injection system settings, the $^{56}Fe^{10+}$ ion beam was injected into the chamber of the cyclotron.

Table 1. Calculated parameters of the acceleration mode for $^{56}Fe^{10+}$ ions.

Atomic mass of ion	56
The charge of the ion	10
Mass to charge ratio A/Z	5.6
Field B_0, T	1.518
Field B_e, T	1.5209
The ion energy, MeV/nucleon	1.75
The current of the main magnet, A	249.2
The frequency of the RF generator, MHz	16.650
RF harmonic number	4
The injection voltage, kV	16.7
Type of inflector	“A”
Inflector voltage, kV	±6.7

In order to provide the maximum capture of the beam into the acceleration mode some improvements of the RF generator matching were performed, which result in the increase of TWR at a fixed workload of amplifying tetrode.

The optimization of cyclotron settings for the acceleration of $^{56}Fe^{10+}$ ions was performed. We investigate the influence of correction and azimuthal coils for magnetic field formation. The accelerated beam current at the extraction radius of the cyclotron obtained after optimization of operating modes of the axial injection system and of the cyclotron constitutes of 613 nA.

Figure 2 shows the radial dependence of the accelerated ion beam. It is seen, that radial distribution of the beam is almost uniform.

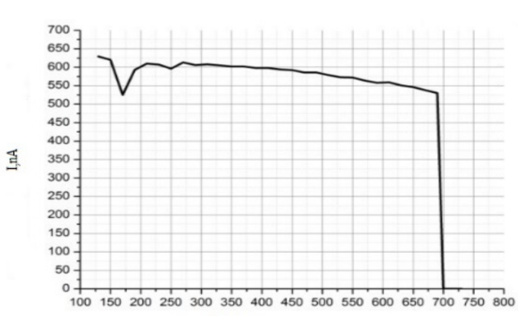

Figure 2: Radial dependence of the accelerated ion beam

Figure 3 shows the resonance curves of accelerated ion beam. The coincidence of the beam current maximum at different radial probe position indicates the correct configuration of the magnetic field.

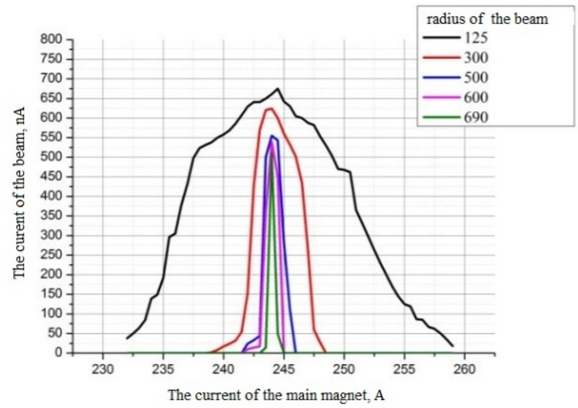

Figure 3: Dependence of $^{56}Fe^{10+}$ ion beam current from the level of magnetic field at different radius.

For production of the maximal current of the extracted ion beam the influence of the positions of the septum and potential deflector plates, and also deflector potential on the intensity of the extracted beam was studied. After optimization the extracted beam intensity of 240 nA was achieved.

$^{56}Fe^{10+}$ ion beam with the intensity of 241 nA was produced in the target chamber, thus the efficiency of beam transport from the extraction radius of cyclotron to the target constitutes of 39 percent.

CONCLUSION

As a result of performed work for the first time at the DC-60 cyclotron the accelerated beam of iron ions was obtained with the use of MIVOC method. After optimization of the ion source and acceleration mode settings 630 nA and 240 nA of $^{56}Fe^{10+}$ ions were obtained at the cyclotron extraction radius and in the transport channel correspondingly.

The widening of the range of accelerated ions increase the possibilities for the experiments in the field of nuclear physics, radiation physics of solids and various applications at the DC-60 cyclotron complex.

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