Ion Source DECRIS-3.

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Introduction.

The ECR ion source DECRIS-3 is the copy of the mVINIS ion source[1] which was designed and built in Dubna for the TESLA Accelerator Installation (Belgrade, Yugoslavia) in 1997. The mVINIS ion source is an ECR ion source designed to be an injector for the VINCY Cyclotron as well as stand alone machine for the low energy experiments. The first beam in Belgrade was obtained in September of 1997. After improving its control system in the beginning of 1998, the mVINIS ion source was completed with the low energy experimental channel and wide range of experiments with gaseous ions were carried out. The first operation of the mVINIS ion source have shown high capabilities and reliability of this machine, especially in the case of moderate charge state ions.

The ECR ion source DECRIS-3 has been built over the last year to use especially on the FLNR ECR test bench. The main goal of this installation is the design of new technologies to upgrade an ECR ion source performance thereby providing new research opportunities at cyclotrons. Here we present the description of the source design and the first results obtained with the DECRIS-3 ion source. We also present the developments and upgrades are planned to be performed in the nearest future.

Source design.

The ion source DECRIS-3 is the upgrade version of the DECRIS-2 ion source which is in operation at the U-400M cyclotron during the last four years.

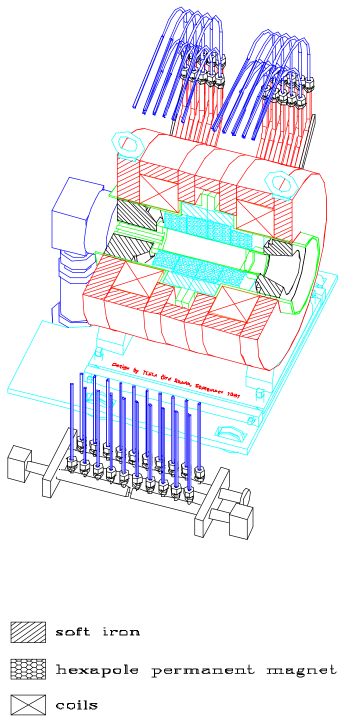

Fig. 1. Schematic overview of the DECRIS-3 ion source.

The cross section of the ECR ion source is shown in Fig. 1. It shows the complete ion source assembly including solenoid coils and iron yoke, double wall plasma chamber, microwave injection box with microwave input and simple two electrode extraction system. For the production of metallic ions the source allows the installation of high temperature microovens and sample insertion for sputtering through the central conductor of the coaxial wave guide (injection part of the plasma chamber). This conductor is insulated from the body of the source and can be used as a biased electrode. While the overall design of the DECRIS-3 is similar to its predecessor, there are some significant differences. The magnetic system of the source takes into account the latest understanding that a high axial mirror ratio as well as a strong radial magnetic field inside the plasma chamber are very important parameters to provide better plasma confinement[2]. We therefore decided to upgrade the ECR source by increasing its axial magnetic field. The source axial length was shortened 5 cm. Compare to the prototype we used for each coil only 5 (instead of 6) double-layer pancakes made from smaller hollow core copper conductor, but number of turns for each pancake were increased. The shape of the magnetic field shaping plugs was also slightly changed. As a result the maximum axial peak magnetic fields increase from 0.86 to 1.08 Tesla at extraction and from 11.4 to 12.9 Tesla at injection with no increase in dc power.

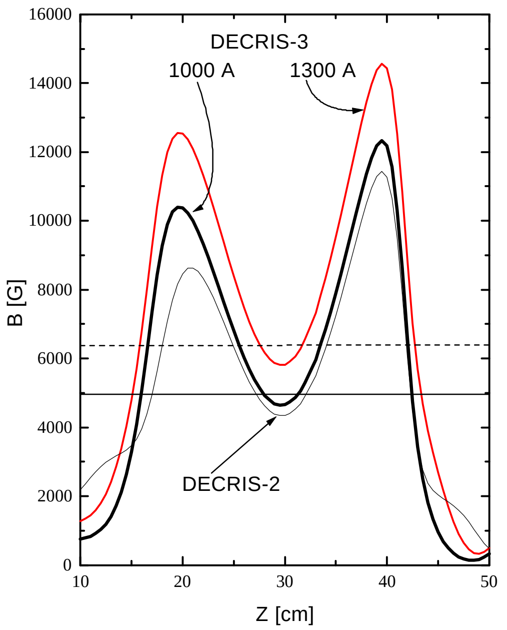

Fig. 2. Axial magnetic field distribution of the DECRIS-3 ion source.

Fig.2 shows the comparison between the axial magnetic field distribution for the prototype and mVINIS ion sources

The DECRIS-3 ECR ion source is still driven by 14 GHz frequency heating. If the power supplies will be capable of providing up to 1300 A to each coil the axial magnetic field distribution will be suitable to use 18 GHz frequency heating. The main parameters of the ECR ion source are collected in Table 1.

Table 1. Main parameters of the DECRIS-3 ion source.

MAIN PARAMETERS	
f	14 GHz
W_{total}	68 kW
B_{inj}	1.29 T
B_{min}	0.46 T
B_{extr}	1.08 T
L_{mirror}	20 cm
Source length	40 cm
Source diameter	44 cm
Plasma chamber diameter	6.4 cm
COILS	
I_{max}	1000 A
U_{max}	34 V
ΔP [Bars]	≤ 10
ΔT	25^0
Cooling water consumption	2.5 m^3/h
HEXAPOLE	
Material	NdFeB
Internal diameter	7 cm
Hexapole field on the chamber wall	1.0 T

The ion source DECRIS-3 was successfully tested at the FLNR ECR test bench with some gases and metals by using the MIVOC technique. It is interesting to note that the performance of the source similar to the performance of its predecessor was reached very easy with the comparatively low microwave power (< 200 W). Unfortunately it was impossible to rich the same ion yields as for mVINIS ion source in Belgrade because of the worse vacuum conditions in our test bench. The comparison between ion yields for DECRIS-3 and its predecessor can be seen in Fig. 3.

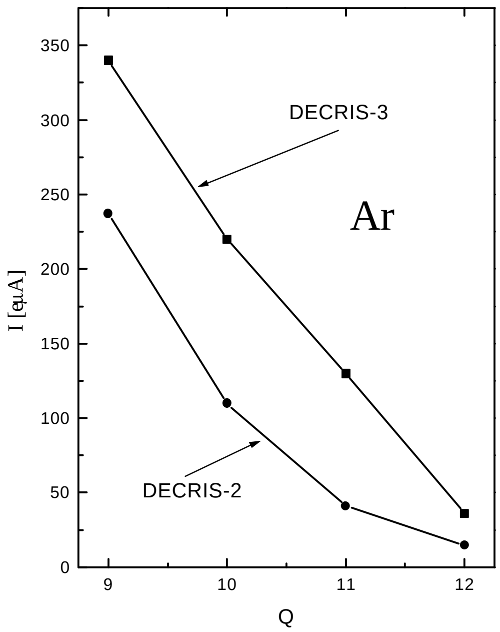

Fig. 3. Comparison of the typical ion currents from the DECRIS-3 ion source and its predecessor.

Planned upgrades and investigations

In the nearest future the following developments and investigations are planned to be performed at the ECR test bench:

- Detailed investigation of the source performance with the frequency of 14 GHz.
- According to the scaling law proposed by R.Geller, the beam intensity increases with the microwave frequency and magnetic field strength. For this reason we are going to test the source with the frequency of 18 GHz.
- The performance of the DECRIS-3 ion source could still be improved if a second microwave frequency is added to drive the plasma.
- The special task is the optimization of the ion source parameters for the efficient production of the ^{48}Ca ion beam.

DRIBs project.

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 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}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. Simultaneously, the other accelerator may be switched off or used in an individual mode of operation. The complete scheme of the project is shown in Fig. 4.

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. The project also assumes the design of 1+ $\Rightarrow$ n+ ion conversion devices[3,4]. The ion source DECRIS-3 will be used for the basic research connected with this problem.

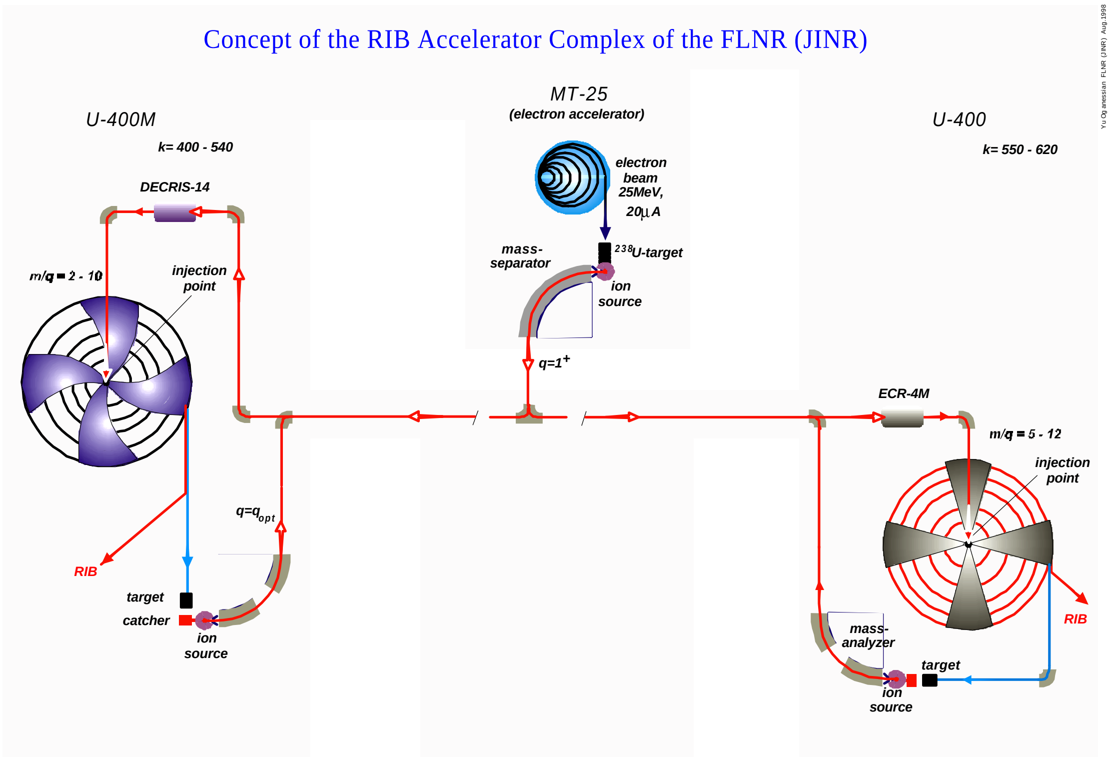

Fig. 4. The scheme of location of the MT-25 microtron and the U-400 and U-400 M cyclotrons connected by a transport line. Different variants of radioactive beam injection into the cyclotrons are shown.

References.

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