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A.A.Efremov, V.B.Kutner, A.N.Lebedev,
J.Pivarč*, V.A.Chugreev

# ION SOURCE DECRIS

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*Institute of Physics, Slovak Academy of Sciences,
Dúbravská cesta 2, 842 28 Bratislava, Slovakia

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## I. INTRODUCTION

The design of the ECR multicharged ion source DECRIS (Dubna ECR Ion Source) was started at the Laboratory of Nuclear Reactions, JINR in 1989 and in January of 1992 the first plasma was ignited. The classical magnetic configuration based on MINIMAFIOS [1] with some 'features' had served as the basis for source design. Magnetic structure like MINIMAFIOS is easily changed by the moving of coils or using of additional soft iron shims thereby making it very convenient to study the ion source magnetic field. There is enough room to install different kinds of UHF feeding, solid material samples, oven or others in this source. We have supposed to use the same water cooling system for both ion source coils and other elements of beamline with only 5 kg/cm$^2$ water pressure. In this case the length of coil conductor and external diameter of coils are restricted to provide needed water flow for coil cooling. For these reason the axial magnetic system differs from the prototype.

## II. DESCRIPTION OF THE ION SOURCE

The scheme of the ion source DECRIS is shown in Fig. 1 and the axial magnetic field distribution is given in Fig. 2. It consists of two stages and is quite similar in size to MINIMAFIOS. In the first stage a cold plasma is ignited and then diffuses towards the second stage with "minimum B" confinement. Both stages have the magnetic mirror configuration. The axial magnetic field is produced by the water cooled solenoidal coils which consume about 130 kW. The discharge chamber represents two coupled multimode cavities with internal diameters

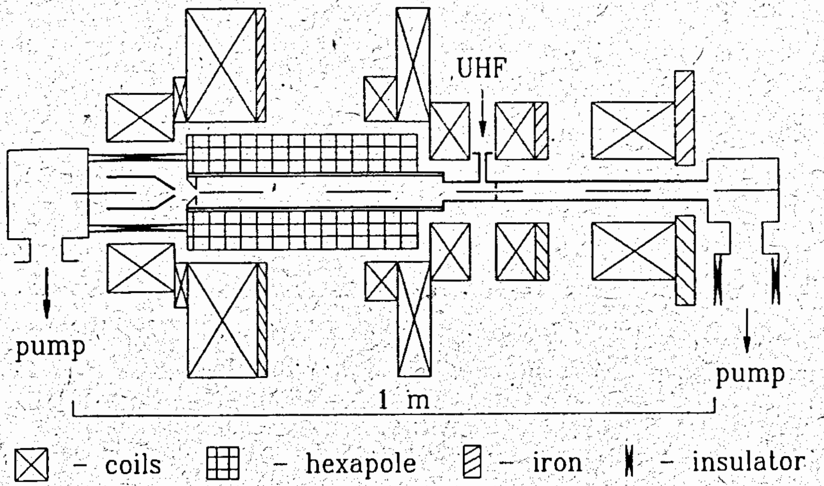

Fig.1. Schematic cross-sectional view of the ion source DECRIS

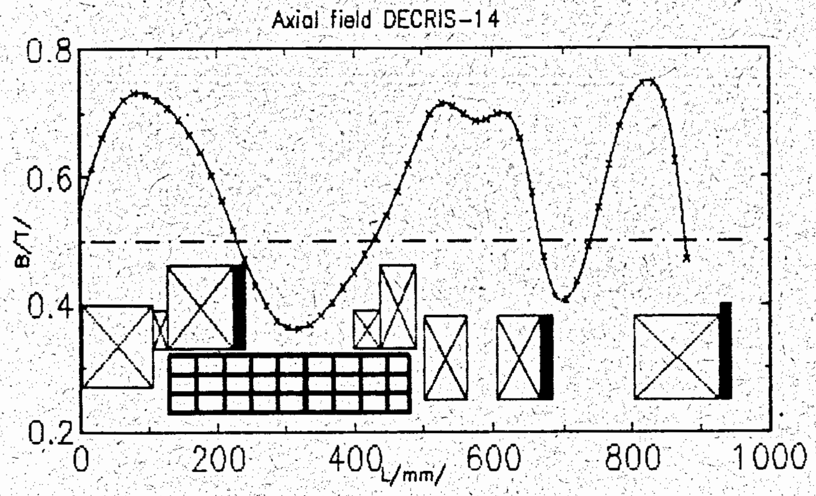

Fig.2. The axial magnetic field distribution

of 42 mm and 64 mm for the first and second stages respectively. The microwave power is injected radially and only the UHF entrance is used for both stages and situated immediately near the maximum axial magnetic field between the first and second stage in order to eliminate wave transmission problems.

The minimum B configuration in the second stage is produced by a superposition of an axial mirror field and radial hexapole field. In Fig.3, there is shown the cross section geometry of the hexapole [2], which was chosen for the DECRIS. The hexapole has a magnetic flux concentration geometry, the same that is usually used for permanent magnet lenses. The hexapole consists of 7 identical slices with length of 5 cm. Each slice includes 12 NdFeB trapezoidal bars with corresponding easy axis direction for each one. Using NdFeB permanent magnets with middle characteristics, (remanent field 1.05 T) the hexapole produces almost uniform total magnetic field on fixed radius with the value of magnetic field on a pole surface more than 1 T (Fig.4). Whole hexapole is 35 cm long and internal diameter of 7 cm. A hexapole thickness is determined not only with respect of providing the needed magnetic field inside the ion source but also in order to minimize the weight and corresponding cost. An increase of hexapole external diameter also significantly raises a power supply for the solenoidal

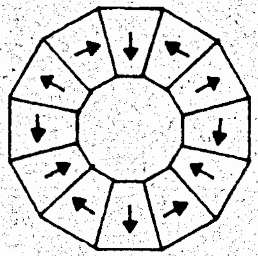

Fig. 3. Hexapole cross section

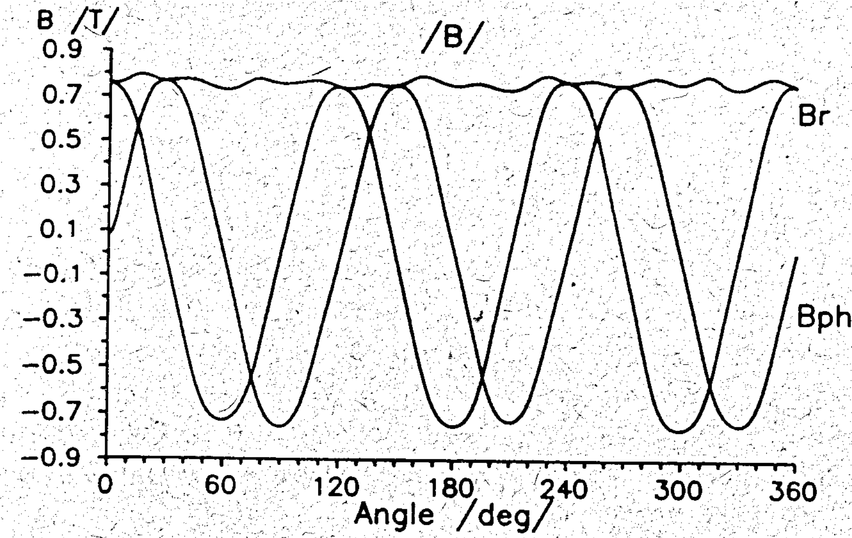

Fig.4. Measured radial $B_r$ and tangential $B_{phi}$ components and total magnetic field B in the middle plane of the hexapole

coils of the ECRIS. Therefore to choose the hexapole thickness the magnetic field calculations for a hexapole with different external diameters were done. According to these calculations 6 cm thickness was used.

A turbomolecular pumping through injection and extraction sides of the source provides 2x10$^{-5}$ Pa background vacuum. The second stage is not separated from the first stage by differential pumping because under using frequency insitu plasma pumping becomes efficient. Two separated adjustable piezoelectric valves are located near the first stage and allow gas mixture. Ion extraction is accomplished by two elements with plasma electrode hole of 8 mm, puller hole of 12 mm and distance between them of 32 mm. The plasma electrode is

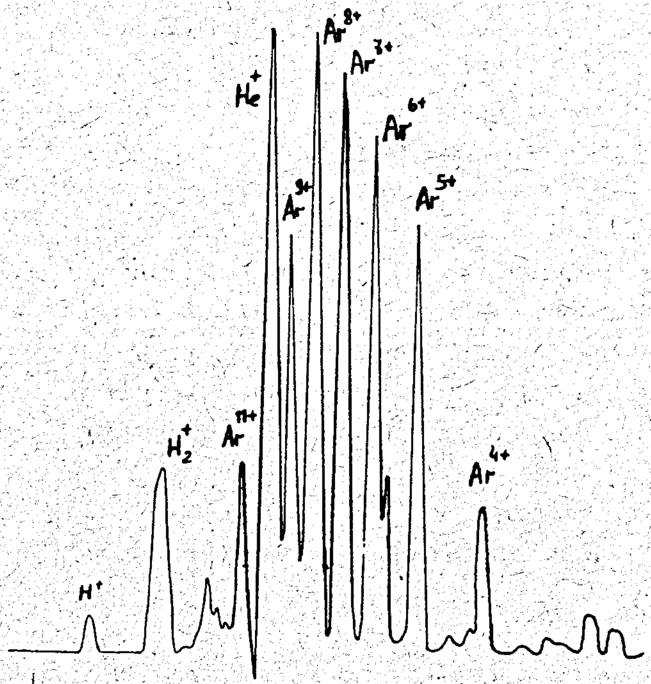

Fig. 5. Argon spectrum, optimized for $Ar^{8+}$

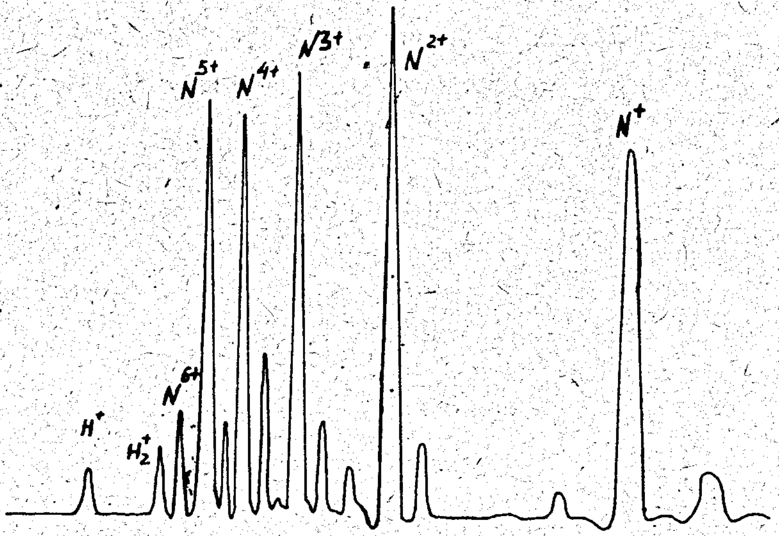

Fig. 6. Nitrogen spectrum, optimized for $N^{5+}$

near the peak of the axial field and its optimum position is now experimentally determined.

The plasma chamber and hexapole are insulated up to 25 kV and connected to high voltage power supply, except of the solenoids and the main and auxiliary vacuum systems and diagnostic line which are grounded. The hexapole water cooling is accomplished through special water denouement by a common water system.

A commercial UHF generator on frequency range of 14.0-14.5 GHz (dependent on klystron) with maximum output power up to 2.0 kW is used for microwave power supply. Generator is connected to ion source through high voltage insulator and tight BeO window.

The only adjustable parameters are the gas flow, microwave power, axial magnetic field and extraction voltage. In our configuration, every adjustable parameter is manually operated from the operating room which is about 40m far from the ion source.

## III. THE RESULT OF RECENT EXPERIMENTS

DECRIS was installed on the ECR test bench, which includes beam line, 90- degrees analyzing magnet and some equipment for beam characteristics investigation. The first study of the source was carried out in continuous mode under strict control of hexapole temperature. Generally after magnetic field intensity and gas tuned, from 85 to 95% of the microwave power was absorbed in the cavity.

The ion source has been tested with the argon, oxygen and nitrogen. In Figs. 5 and 6 there are shown preliminary results obtained from the DECRIS. The production of typical ECRIS spectra of multicarged ions shows that the DECRIS is a reliable ion source able to run in continuous mode of operation at different UHF powers. The typical UHF power consumption is 200 - 700 W. It is also shown that the helium, nitrogen and oxigen injection into ion source, where argon ions are expected, improves the yields of high charge state argon ions. Some typical data are summarized in Tab. 1.

Table 1. The ion currents (eμA) from DECRIS. $U_{ext}$=10 kV

| Ion | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ |
|---|---|---|---|---|---|---|
| N | 270 | 92 | 17 | | | |
| O | | 160 | 87 | 26 | | |
| Ar | | | | 120 | 110 | 70 |

## IV. CONCLUSION

As follows from the last results the present configuration of the DECRIS has to be slightly explored in order to reach both higher charge state ion beams and intensity. The following fields of efforts are considered :

- some changes in magnetic field configuration;
- increase of the effective pumping speed in the extraction region;
- investigation of different constructions of the first stage;
- fine regulation of the gaseous supply.

## REFERENCES

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2. A.A.Efremov et al., X All-Union Conference on Permanent Magnets, October 1991, Sandal, M. 1991, p. 198

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