Two-Frequency Upgrade to the Texas A&M ECR Ion Source ECR2

D. P. May and G. J. Derrig

Introduction

We have received funding for another ECR ion source upgrade, and have decided that the success of the two-frequency, high-field operation of the U-AECR at LBL [1] points in the most promising direction. Since ECR1 is in almost constant use, ECR2 will be modified in an effort to obtain even higher performance than that of ECR1, and the 1.5 kW, 14.5 GHz transmitter left idle since the upgrade of ECR1, will be put to use again on ECR2. For one calculated field configuration, a closed ECR surface at 6.4 GHz would exist inside a closed ECR surface at 14.5 GHz, allowing two frequency operation without the acquisition of a new transmitter. 10-14.5 GHz operation can be tried with the acquisition of a 10 GHz transmitter. Several more higher current power supplies would be needed for optimum performance in this mode.

Upgrade to Multiple-Frequency Operation

As illustrated in Fig. 1, the ECR2 ion source was constructed around the 0.3 Tesla hexapole removed from ECR1. Figure 2 shows the proposed reconfiguration of the ECR2 source. The iron yoke will be extended, and the two groups of coils will be separated further. An iron plug similar to the one on ECR1 will be added on the injection end, and a steel ring will be incorporated into the extraction plate. The axial field that can be achieved with the available current supplies is shown in Fig. 3 as well as the field produced when all eight coils are supplied by 500 A, the safe limit for the coils.

Figure 4 shows a cross-section of the hexapole. Using Nd-Fe-B permanent magnet material, specifically UGIMAX 43A, it will have a pole strength of 0.88 T on the wall and a gap strength of 0.67 T, assuming nominal magnetic properties for the supplied material. This field configuration is similar to that of the U-AECR [1]. Space between the magnets is available for holes for pumping and for insertion of ovens and sputtering devices. The plasma chamber will be constructed similarly to that of ECR1, i.e. fabricated of aluminum and water-cooled with clamped-on copper tubing. In deflection studies, the maximum deflection of the aluminum caused by vacuum loading plus the magnetic forces between the poles was 0.01 mm. Also cooling calculations assuming a 1.5 kW heat load and an initial temperature of 30°C gave 38°C as the maximum temperature in the aluminum. The Curie temperature of Nd-Fe-B is about 310°C. The diameter of access holes drilled through the aluminum will be 12.7 mm. At a minimum, there will be a total of nine of these holes, with a set of three closely spaced in each 120° sector. A biased plate will be located on the injection end.

The hexapole will be assembled from 9.47 cm long sections of uniformly magnetized material. Twelve sections will be used for each of the six bars. First the sections will be glued and pinned into the 56.82 cm long bars. The bars will be inserted radially into slots in the hexapole holder, and to minimize distortion all six will be arranged symmetrically and simultaneously moved into place.

The fields available for the reconfiguration are listed in Table I and, with other source parameters, are compared to U-AECR. The normal operating field at extraction for the U-AECR is between 0.8 and 0.9 T [2], so the fields should be very similar. The axial fields listed for 6.4-14.5 GHz operation can be produced with the power supplies available. The only major difference between the two sources will be that ECR2 will have roughly six times the volume of U-AECR, which could have advantages both in source stability and in dissipation of wall heating from the plasma.

Conclusion

The delivery of the permanent magnets is scheduled for June 1999, so the construction phase of the upgrade for ECR1 should be completed by the end of August of 1999. Initially, the source can be run with the lower axial field profile, and 6.4-14.5 GHz operation can be attempted. Later, when each coil is powered by a high current supply, the higher field profiles can be used with 14.5 GHz operation. Finally 10-14.5 GHz operation can be tried after acquiring a high power 10 GHz transmitter.

It will be interesting also to compare the performance of the upgraded ECR2 with that of ECR1 both operating in 6.4 GHz single frequency mode. However, with higher fields and multiple frequencies, the performance of ECR2 should be markedly improved over that of ECR1.

Table I. Source design parameters.

HEXAPOLE	TAMU Design	U-AECR [4]
Wall strength of the magnetic field at the pole	0.88 T	0.85 T
Bore diameter of plasma chamber	13.2 cm	7.6 cm
AXIAL FIELD		
Peak field at extraction for 10-14.5 GHz	0.9 T	1.1 T
Peak field at extraction for 6.4-14.5 GHz	0.8 T	
Peak field at injection for 10-14.5 GHz	1.5 T	1.7 T
Peak field at injection for 6.4-14.5 GHz	1.3 T	
Intermirror distance	56.3 cm	28.5 cm

References

[1] Z.Q. Xie and C.M. Lyneis, *Proceedings of the 13th International Workshop on ECR Ion Sources*, College Station, Texas (1997) 16.

[2] Z.Q. Xie, private communication.

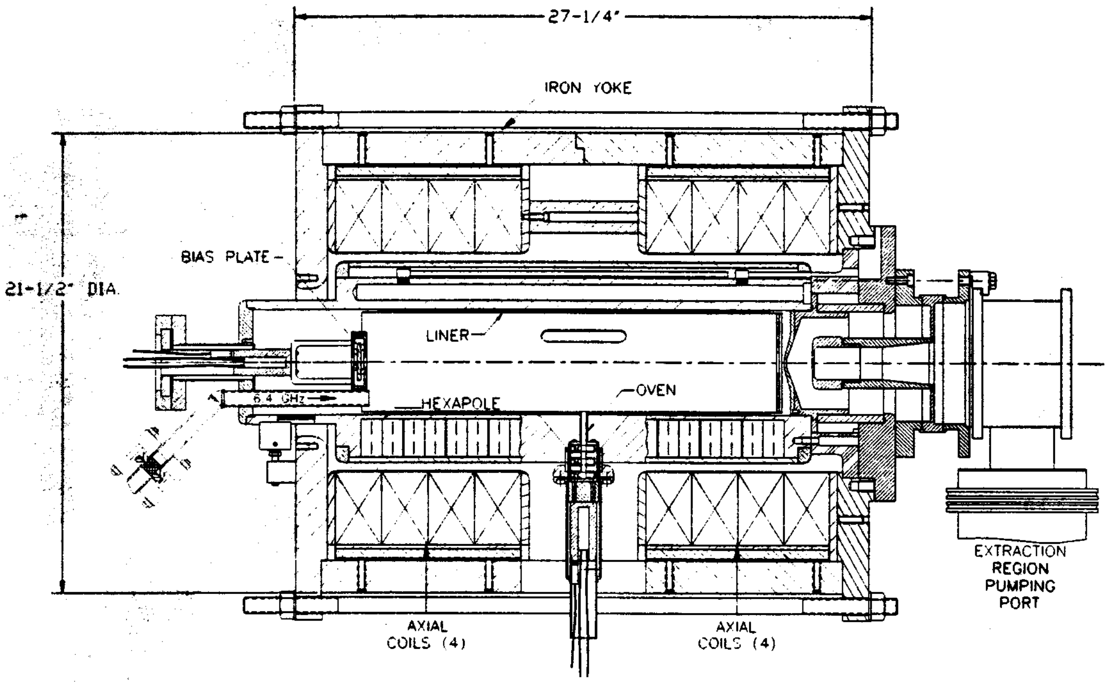

Figure 1. Longitudinal cross-section of ECR2 before upgrade.

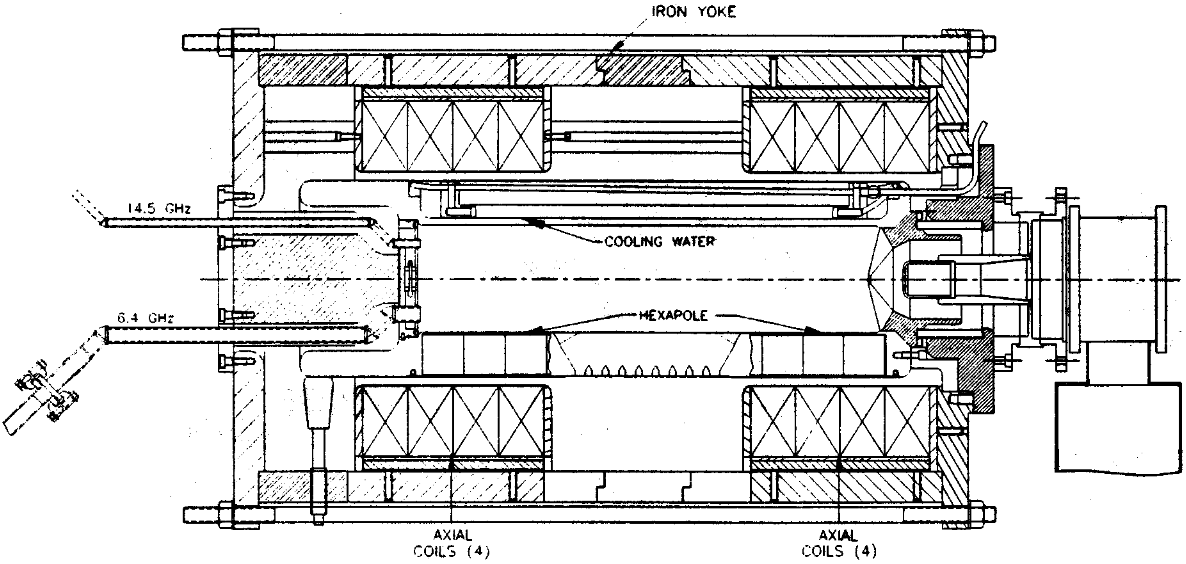

Figure 2. Longitudinal cross-section of ECR2 after upgrade.

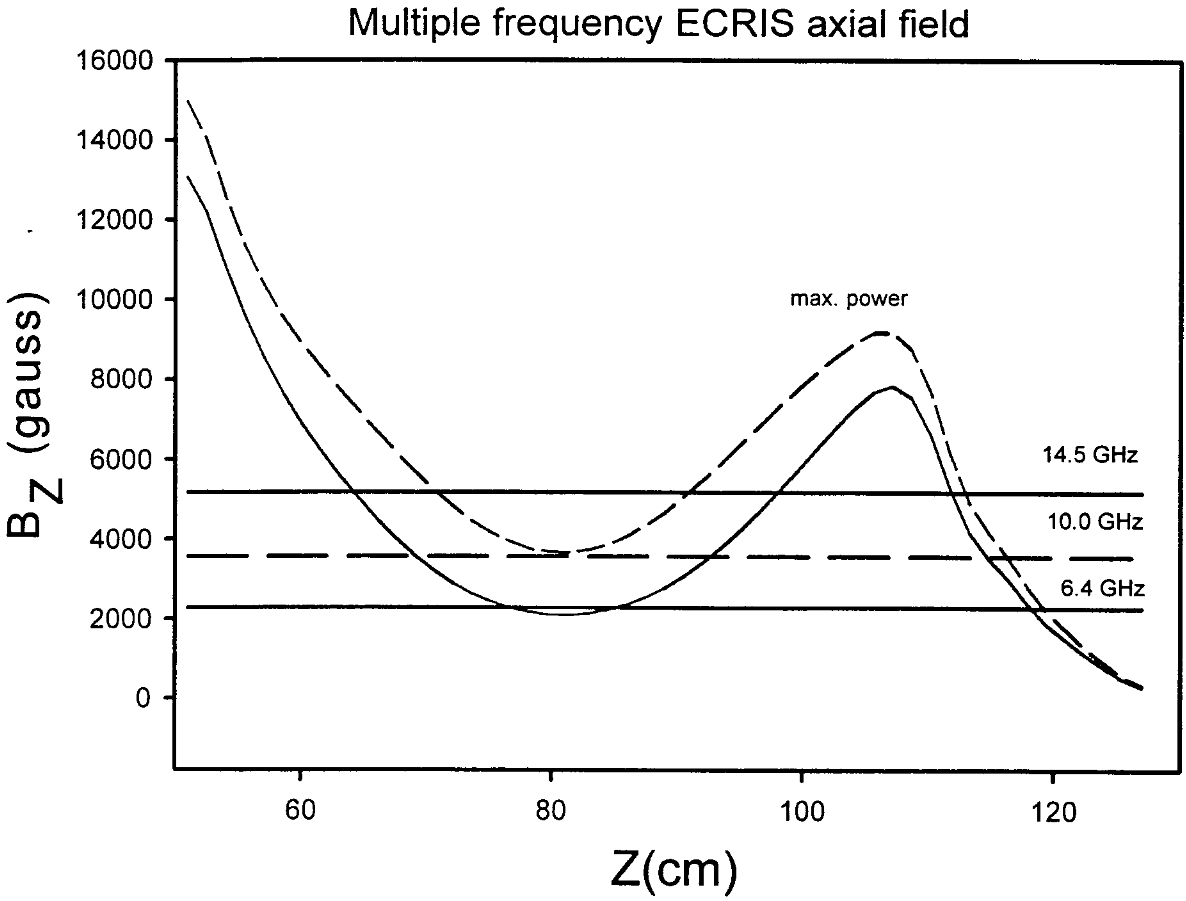

Figure 3. Axial field of source showing initial field and maximum field.

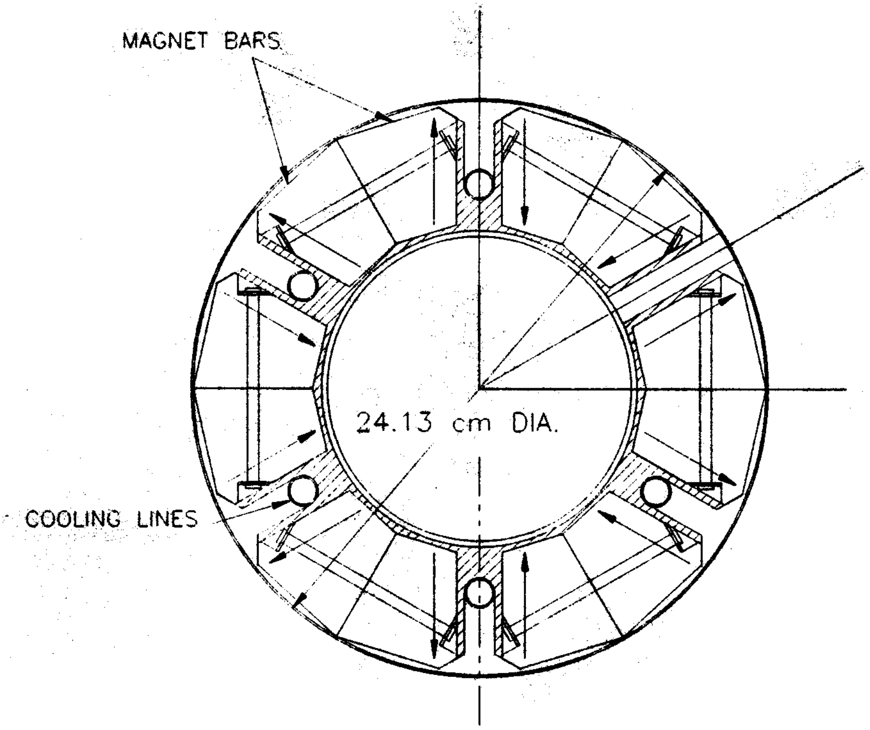

Figure 4. Cross-section of hexapole.