Performance of the upgraded LBL AECR Source *

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The LBL AECR source has been upgraded (AECR-U, shown in Figure 1) in July 1996 by increasing its magnetic fields to improve the plasma confinement therefore to enhance the source performance. The new solenoid magnets have pancakes with larger hollow core copper conductor and thicker magnet iron return yokes. Iron plugs are also used to concentrate the field flux in the plasma chamber. With these improvements, the maximum peak axial magnetic field strengths increase from 1.0 to 1.7 Tesla at the injection and from 0.7 to 1.1 Tesla at the extraction region, respectively, with no increase in ac power. A new set of NdFeB permanent sextupole magnet with a nominal magnetic remanence Br of 1.3 Tesla was installed in the aluminum plasma chamber to raise the maximum radial field strength. To ensure sufficient cooling, the permanent sextupole magnet bars are enclosed in 0.25 mm thick watertight stainless steel cans and are directly water cooled. The maximum sextupole field strength at the chamber inner surface is 0.85 Tesla.

After a few months of tailoring the magnetic field configuration to match the incoming microwaves of 14 and 10 GHz (two-frequency plasma heating), the AECR-U source with its higher magnetic fields and increased magnetic mirror ratios has demonstrated significantly enhanced performance. So far the AECR source has produced many record beam intensities and high charge state heavy ions from an ECR source. For heavy ions at intensity of about 1 eμA, the charge state was shifted from 42+ to 48+ for the heaviest natural element--uranium and from 41+ to 46+ for bismuth. An order of magnitude enhancement for fully stripped argon ions (I ≥ 60 enA) also has been achieved. For elements of mass from 40 to 86 and intermediate charge state, i.e., mass to charge ratios of 4 to 5, intensities of 100 to 300 eμA were also produced. These ion beams will be used for the BGS detector under construction at the 88-Inch Cyclotron. High charge state ion beams of xenon-136 and uranium-238 produced by the source were injected into the 88-Inch Cyclotron. After acceleration to energies greater than 10 MeV/nucleon for xenon-136 and 6 MeV/nucleon for uranium, the extracted beam intensities from the cyclotron are $1x10^7$ pps for xenon 41+ and a few hundreds pps of xenon 46+. In the identification of the high charge state uranium ions, the transmission was less than 0.01% for these highly-charged ions due to the poor vacuum in the cyclotron. Nevertheless, charge states up to 60+ uranium ions were confirmed with a crystal detector. Uranium 60+ at a few pps with a total energy of 1.935 GeV, the highest beam energy ever produced by the 88-inch cyclotron, was measured.

Footnotes and References

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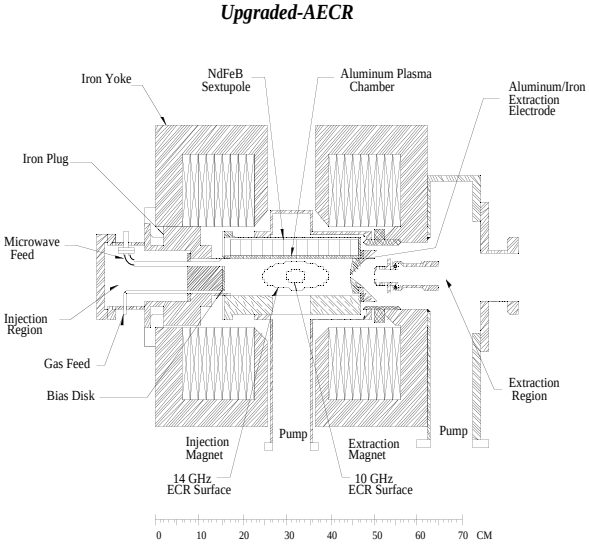

Fig. 1. A cross-section view of the upgraded AECR (AECR-U) ion source.