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A New 14 GHz Electron-Cyclotron-Resonance Ion Source (ECRIS) for the Heavy Ion Accelerator Facility ATLAS - A Status Report

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Abstract

A new 14 GHz ECRIS has been designed and built over the last two years. The source, which is a modification of the AEGR at Berkeley^{1,2} incorporates the latest results from ECR developments to produce intense beams of highly charged ions, i.e. an improved electron confinement with an axial magnetic mirror ratio of 3.5 and a radial magnetic field inside the plasma chamber of 1.0 T. The aluminum plasma chamber and extraction electrode as well as a biased disk on axis at the microwave injection side donate additional electrons to the plasma, making use of the large secondary electron yield from aluminum oxide. Slots in the plasma chamber allow for radial pumping which proved to increase the performance of the AEGR. The source will also be capable of additional ECR plasma heating using two frequencies simultaneously to increase the electron energy gain for the production of high charge states. To be able to deliver usable intensities of the heaviest ion beams the design will also allow for axial access for metal evaporation ovens and solid material samples using the plasma sputtering technique. The main design goal is to produce several e μ A of U³⁴⁺ in order to obtain coulomb-barrier energies from ATLAS without further stripping.

Introduction

This new ECR ion source has been constructed as an improved high charge state injector for the heavy ion accelerator facility ATLAS. The ion source and all associated components will be mounted on a high voltage platform designed for 300 kV operation. The design goal of producing usable beam intensities of heavy elements such as uranium, lead or gold in charge states sufficiently high so that acceleration to the coulomb barrier is possible without foil stripping will increase the beam intensity available for experiments by at least an order of magnitude. In addition to that the beam quality should be significantly improved over beams requiring stripping for acceleration.

Source Design

The mechanical set-up of this single stage ECRIS is shown in fig. 1. It shows the complete ion source assembly including solenoid coils and iron yoke together with a

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cross sectional view of the microwave injection box with microwave inputs for the two frequencies and a detail of the movable puller electrode assembly. The magnetic system for confining the hot plasma electrons takes into account the latest understanding that a high axial mirror ratio as well as a strong radial field inside the plasma chamber are extremely important parameters for improving the performance of high charge state ECRIS. Fig. 2 shows the calculated (POISSON-code³) axial magnetic field on axis produced by two solenoids each consisting of 9 double layer pancake coils with 16 turns per layer and a surrounding iron yoke and plugs at a coil current of 450 A. The power supplies are capable of providing up to 750 A to each pan cake. The hexapole magnet mounted into the aluminum plasma chamber consists of 6 double trapezoidal NdFeB magnets produces a maximum radial field of 1.0 T inside the plasma chamber. This open permanent magnet structure also allows for radial pumping. The ion source also features the possibility of heating the plasma with two different frequencies simultaneously (cross sectional view of the injection tank in fig.1) to increase the energy gain of the plasma electrons to improve the production of high charge states. For the production of metallic ions the source allows the installation of high temperature ovens and sample insertion for sputtering, through the magnetic field shaping plug between injection tank and plasma chamber. The total power consumption of the ion source (including solenoid power supplies and RF generators) is expected to be around 110 kW.

Two different extraction aperture geometries (both with 8mm aperture hole) will be tested for optimizing efficient extraction of high charge state ion beams. The Accel-Decel puller electrode assembly (shown in detail in fig. 1, 9mm hole diameter) is movable along the beam axis allowing adjustment of the extraction system for operation with different ion species. The Accel- or screening electrode is introduced into the main extraction gap and biased to a sufficiently low potential (up to -2 kV) so as to create a negative potential well and form an electron trap to reduce the space charge influence of the ion beam⁴. The calculated normalized emittance of an extracted $^{238}\text{U}^{30+}$ ion beam using the IGUN code⁵ with typical ECR plasma parameters ($n_p = 1 \times 10^{11} \text{ cm}^{-3}$, $T_i = 5 \text{ eV}$, total extracted current $I_t = 1 \text{ mA}$) is $\epsilon_{n90\%} = 0.2 \pi \text{ mm mrad}$ at 12.5 kV extraction voltage. A first plasma is expected in early fall 1996.

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Figure captions:

Fig. 1: Schematic overview of the 14 GHz ECR 2

Fig. 2: Axial magnetic field on axis at 450 A coil current through all pancakes
calculated using the POISSON code³

Figure 1:

