A NEW ROOM TEMPERATURE ECR ION SOURCE FOR ACCELERATOR FACILITIES

D. Hitz, D. Cormier, J.M. Mathonnet

CEA –Grenoble, Direction des Sciences de la Matière, Département de Recherche Fondamentale sur la Matière Condensée, Service des Basses Températures, 17 Rue des Martyrs, 38054 Grenoble Cedex 9, France

Abstract

Magnetic scaling laws have recently been determined for the optimization of any Electron Cyclotron Resonance Ion Source (ECRIS). According to these scaling laws, a new 18 GHz room temperature ECRIS has been built to deliver intense beams of medium and high charge states. To achieve an efficient electron heating, additional frequencies could be used at the same time. After a presentation of magnetic scaling laws, a description of the source will be done, the preliminary results are presented.

1 INTRODUCTION

For long term experiments required by accelerators, an ion source has to be easy to handle, reliable and powerful. Today accelerators are now demanding high intensity beams up to 1emA in continuous or pulsed mode. Recent experiments performed with the Serse **E**lectron **C**yclotron **R**esonance **I**ons **S**ource (ECRIS) have determined magnetic scaling laws governing ECRIS [1-2]. It has been demonstrated that the highest frequency heating could be used with an appropriate magnetic confinement. However, in order to still improve the ECRIS performances, one has built a new room temperature ECRIS, called Grenoble Test Source (GTS), whose purpose is to be a powerful ion source flexible enough to test new ideas (electron source, RF heating, RF coupling, etc.). This article deals with the preliminary results obtained with GTS.

2 ECRIS SCALING LAWS

An ECRIS is a small mirror machine equipped with a radial minimum-B magnetic multipole. The electron are heated by interacting with a radio frequency wave at cyclotron resonance when crossing the closed equal-$|B|_{ecr}$ surface, where the electron Larmor frequency is equal to the rf wave frequency.

The first main component of an ECRIS is the magnetic confinement (axial and radial). Scaling laws performed with the SERSE source are presented in **Figure 1** for the axial magnetic filed on the injection side of an ECRIS. Whatever the frequency heating, an optimised source must have an axial field equal to 4 times the corresponding resonance field.

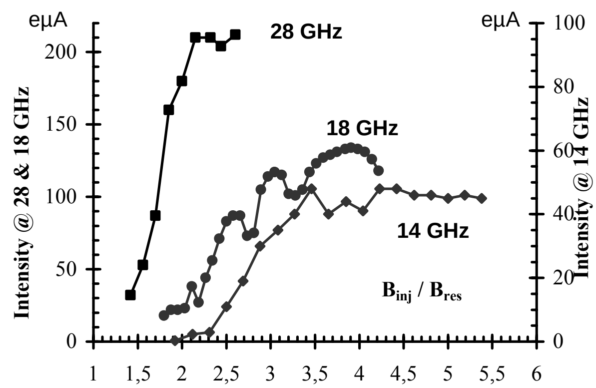

Figure 1 : influence of the axial magnetic field on Xe^{20+} in dc mode (20 kV extraction)

In **Figure 2** is shown the necessity to have a radial magnetic field being twice the resonance value: a performing ECRIS should have 2.2 T as radial field at the plasma chamber wall.

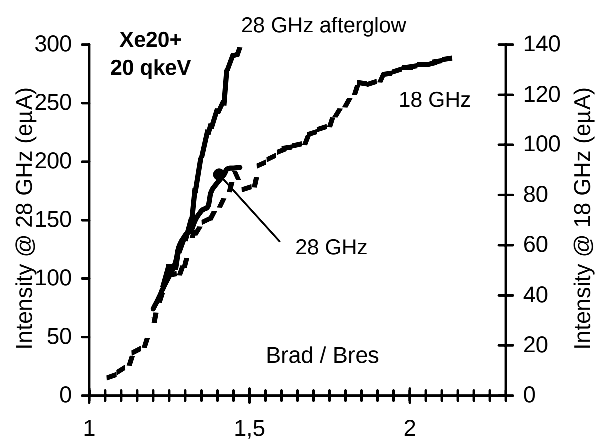

Figure 2 : influence of the radial magnetic field on Xe^{20+} in dc mode (20 kV extraction)

Another important parameter of an ECRIS being the frequency heating, experiments performed with the SERSE ECRIS show that the beam intensity obeys to the so-called frequency scaling: it is proportional to the square of the frequency heating provided that the magnetic profile is similar. **Figure 3** clearly shows this frequency effect.

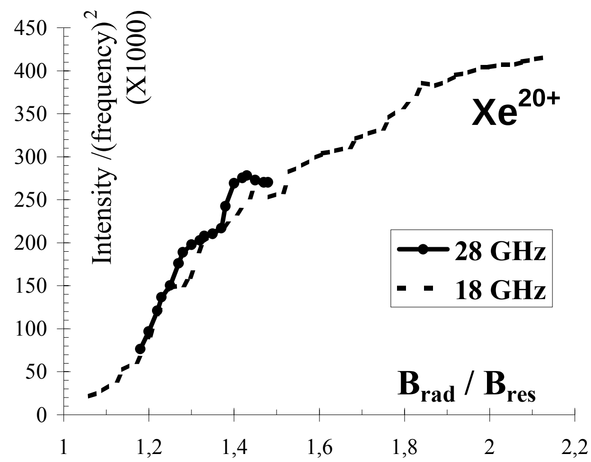

Figure 3 : frequency effect showed by SERSE operated at 18 GHz and 28 GHz with different radial confinements.

3 DESCRIPTION OF GTS

The **G**renoble **T**est **S**ource has been constructed according to the magnetic specification described above. To enhance the magnetic field strength, an iron plug is added on the injection side: in such a way, an axial field of 2.5 T is achievable.

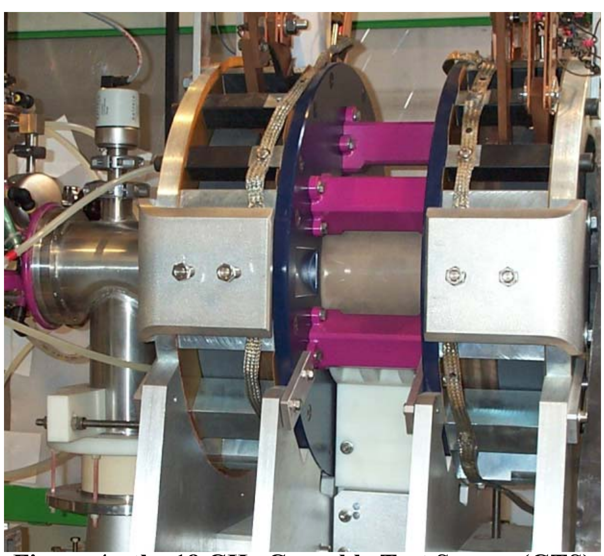

Figure 4 : the 18 GHz Grenoble Test Source (GTS)

The magnetic field value at the extraction is similar to the radial magnetic field at chamber wall, i.e. 1.2 T. The double wall plasma chamber is made of aluminium to enhance the secondary electron emission. The large and long plasma chamber (80 mm in diameter and 300 mm long) allows a long lifetime for the ions in order to produce high charge states. In such a configuration, the 18 GHz resonance is 160 mm long. As it is a source for tests, one has chosen several frequencies : 10, 14 and 18 GHz. All frequencies could be launched together, the ion source being equipped with a 3 wave guides rf injector. The general picture of the source is presented in **Figure 4** while **Figure 5** shows the radial confinement system with the plasma chamber.

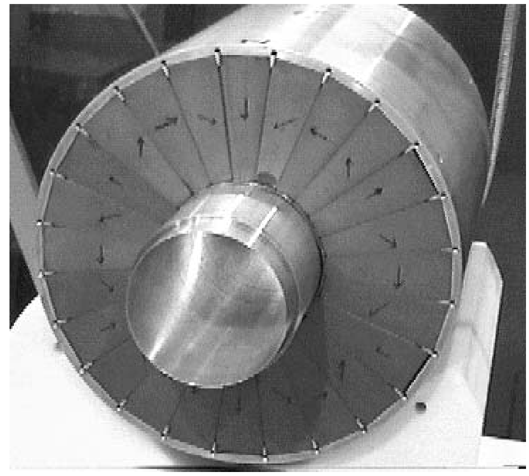

Figure 5 : Grenoble Test Source : hexapole and double wall plasma chamber made of aluminium

4 FIRST RESULTS

4.1 High Charge State Ions Production

This new ECRIS has been first tested at 14 and 18 GHz separately. **Figure 6** shows a typical argon charge state distribution (CSD) when the source is operated at 14 GHz. With a single frequency heating at 14 GHz, an outstanding value has been obtained for a Ar^{14+} beam intensity (60 eμA).

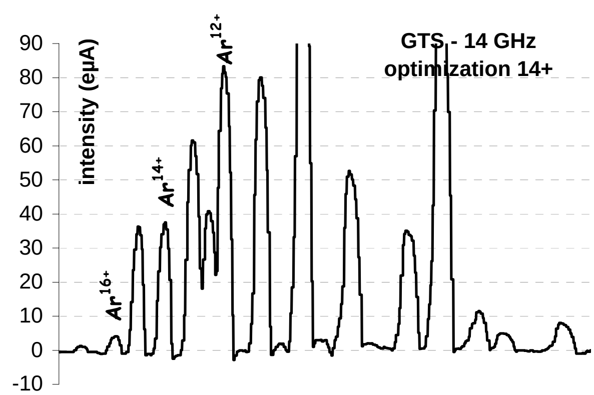

Figure 6 : GTS 14 GHz : Argon Charge State Distribution when the source is optimised on 14+

However, the frequency effect is also demonstrated by GTS. **Figure 7** presents an argon CSD at 18 GHz still with an optimisation on charge 14+. The shift of the CSD towards high charge states is noticeable when comparing **Figures 6 and 7**.

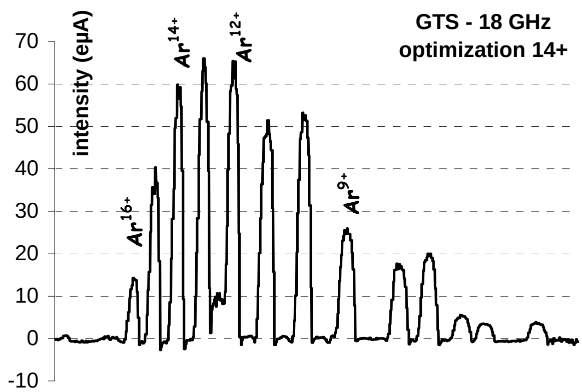

Figure 7 : GTS 18 GHz : Argon Charge State Distribution when the source is optimised on 14+

4.2 High Intensity Beam Production

A specificity of this new ECRIS will be to study the production of high intense beams (above 1mA) of multiply charged ions. The beam intensity level of 1emA has been obtained by GTS for Ar^{8+}. However, it has been noticed that about 25 % of the beam is lost at the extraction region: the electrodes which are used up to now are not rated for a total extracted beam above 3 mA, while about 10 mA are extracted from the source in afterglow mode operation. A special extraction system is under calculation in order to be able to handle intense beams. Despite this today drawback, one has obtained 220 μA of Xe^{20+} at 25kV extraction in dc operation.

4.3 Multiple Frequency Heating

A first test has been performed with xenon to test the influence of the frequency on the beam performance. Preliminary results show that coupling at the same time 10 and 14 GHz is equivalent to launch 18 GHz in the same source but without first stage, which is considered as an electron source (**figure 8)**. Other investigations are under way.

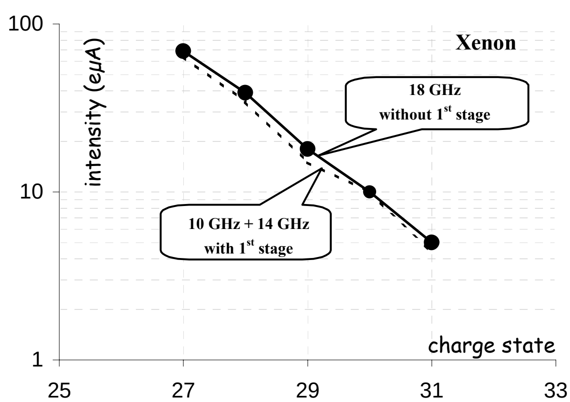

Figure 8: comparison of different frequency heating methods

5 CONCLUSION AND FUTURE PLANS

A new powerful room temperature ECRIS dedicated to the needs of today and future accelerators is now in operation and gives intense beams of medium charge states: 1 mA of Ar^{8+} is obtained in dc mode.

After the improvement of the extraction system, the source will be first used to test the multiple frequency heating : 3 frequencies will be launched at the same time. The purpose of this multiple frequency heating is to not only to enhance the beam intensity but also to get a quiet plasma and consequently a quiet beam. In addition, the multiple frequency heating will be used during the afterglow mode operation in order to obtain a stable beam intensity during the so called afterglow or post discharge mode. Then other techniques to improve the performance of any ECRIS will be tested, e.g. additional electron source (so-called first stage).

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