STATUS REPORT ON CRYEBIS

J.Faure,B.Feinberg*, and P.Antoine,J.C.Ciret,A.Courtois,
L.Degueurce,R.Gobin,P.Léaux,H.Lécroart.
Laboratoire National Saturne,CEN-Saclay, 91191 Gif Sur Yvette Cedex
France

Abstract : Cryebis is the fully stripped heavy ion source for Saturne.Recent results will be discussed. The concept of using a low charge state ion source to inject any desired ions into Cryebis for further ionization has been successfully tested.

Cryebis, an ion source for the production of highly charged ions, is to be installed on the Saturne II synchrotron in the fall of 1983. A brief description of the source and its history will be presented, along with the most recent experimental results.

Cryebis makes use of the stream of electrons from an external electron gun to ionize heavy atoms by successive collisions. The electrons are focussed and conducted through a set of drift tubes by the strong magnetic field (3 Ts) of a superconducting solenoid as shown in Fig.1[1] . Production of highly charged ions depends critically on the product of electron current density and ion confinement time, or $J\tau$. In order to inject, contain the ions for the necessary time,τ, and expel the ions, the drift tubes are biased as shown in Fig.2. Radial containment is provided by the potential well of the electron beam as well as the strong magnetic field. Since the presence of residual gas in the tubes would lead to contamination of the potential well by unwanted ions,and charge exchange, the drift tubes are cryogenically cooled to 4°K to pump any gas.

In spite of excellent experimental results achieved in 1979[2] ,the source has not yet been used to inject ions into Saturne II. Various problems with coolant leaks, magnetic field errors, and the gas injection system made it difficult to obtain reliable, reproducible results. Many modifications have been made[3], the goal of which has been to produce at least 10^9 charges of Ne^{10+} or N^{7+} per pulse, in a reliable manner. Figure 3 shows an example of one problem with the gas injection system. The quantity of ions produced as a function of confinement time depends strongly on the gas used. As shown in Fig.2, the injection potential distribution allows ions produced in the injection zone to migrate into the containment region. Gas is introduced continuously into the injection zone, providing a source of ions. The containment set of potentials is applied next to trap the ions and also to prevent ions from entering the containment zone. Neutral gas, however, is free to travel from the injection zone (at 77°K) to the containment zone (at 4°K). Gases which are pumped at 77°K such as argon, will behave quite differently from gases which are not pumped until they reach the confinement zone, such as neon.

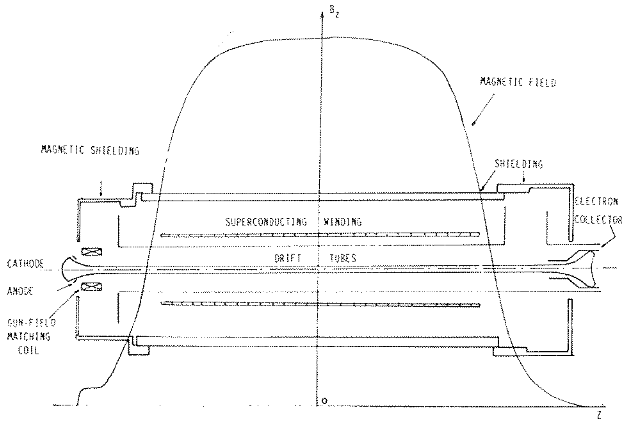

Fig.1 - Schematic of Cryebis

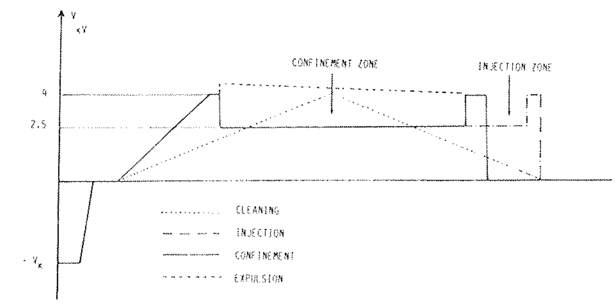

Fig.2 - Drift tube potential distributions

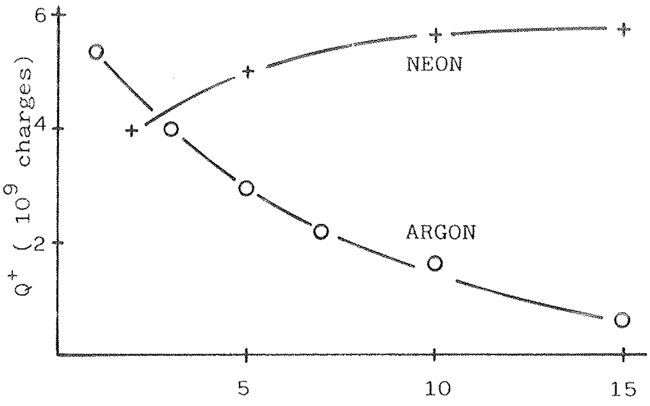

Fig.3 - Quantity of ion charges expelled from Cryebis versus confinement time for Neon and Argon

An external low charge state ion source was developed to resolve this problem. A duoplasmatron is placed downstream from the electron collector, as shown in Fig.4. The source has been successfully tested, and has been shown to be a reliable means of injecting material into Cryebis[4] .

*On leave from Lawrence Berkeley Laboratory.

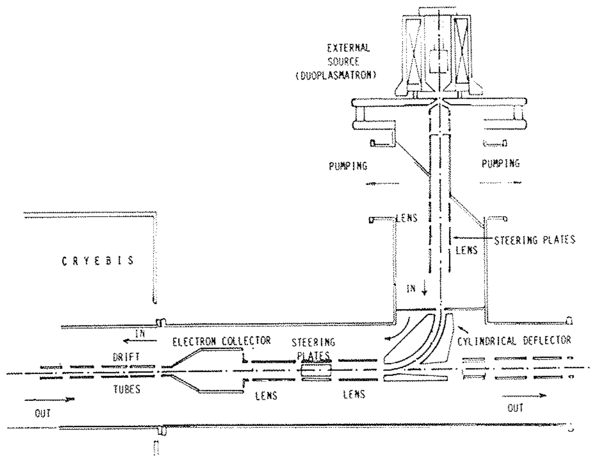

Fig.4 - Schematic of external source arrangement

External ion injection opens up the possibility of injecting solid material into an EBIS, as well as the possibility of rapidly changing materials, even on a shot to shot basis, through the use of multiple external sources.

Another problem, that of ion losses during the containment period, is also shown in Fig.3. This problem is extremely serious since it limits the $J\tau$ and therefore the ability to produce high charge states. In order to reduce the rate at which ions were lost the drift tube diameters were increased. Figure 5 shows the quantity of ions produced as a function of confinement time, for both 5 mm and 10 mm diameter drift tubes. Electron gun, potential distributions, and external source parameters remained approximately the same. As can be seen, the loss rate is much greater for the smaller tubes.

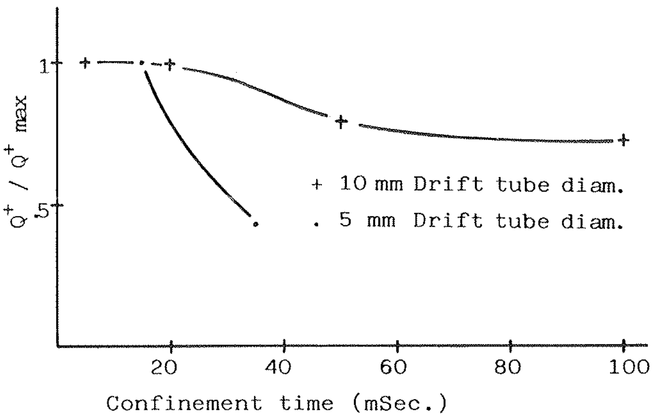

Fig.5 - Quantity of ion charges expelled from Cryebis versus confinement time, for 5 mm and 10 mm diameter drift tubes

Even with the larger diameter tubes, the loss rate was too high to attain the desired charge states. Since classical electron-ion collision processes were too slow to explain the losses[3,5], electron beam instabilities were suspected. In an attempt to reduce this effect, the electron gun current was substantially lowered. Fig.6 shows the quantity of ions produced using a current of only 6 mA.

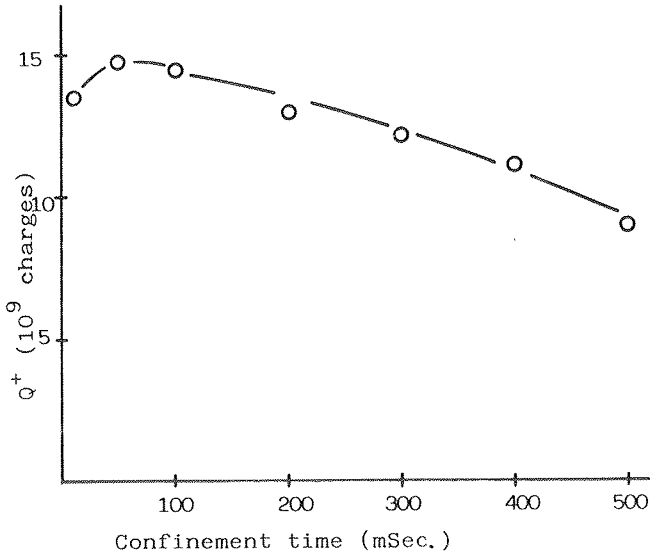

Fig.6 - Quantity of ion charges expelled from Cryebis versus confinement time for an electron gun current of 6 mA.

Even though this mode of operation decreased J, the current density, it allowed a large increase in τ, the confinement time. The charge states produced by this mode of operation are shown in Fig.7, for both nitrogen and neon. About 6 x 10^9 charges of N^{7+} and 1.5 x 10^9 charges of Ne^{10+} per pulse have been produced reliably and reproducibly in this manner.

A mode of operation has been found which reliably produces greater than 10^9 charges of N^{7+} or Ne^{10+}. This enables Cryebis to be installed on Saturne II in the fall of 1983. Improvements will be made in the electron gun system during installation, to produce fully stripped heavier ions, but the present gun system will be retained as a standby to insure reliable operation.

A new source, Dioné, is presently under construction.This source will operate with a magnetic field of 6 Ts and a new electron gun designed particularly for this application and capable of voltages up to 30 kV. The objectives are to produce charge states as high as Xe^{50+} in a time of the order of 15 ms. This source would be used with a storage ring, Mimas, to inject ions into Saturne II.

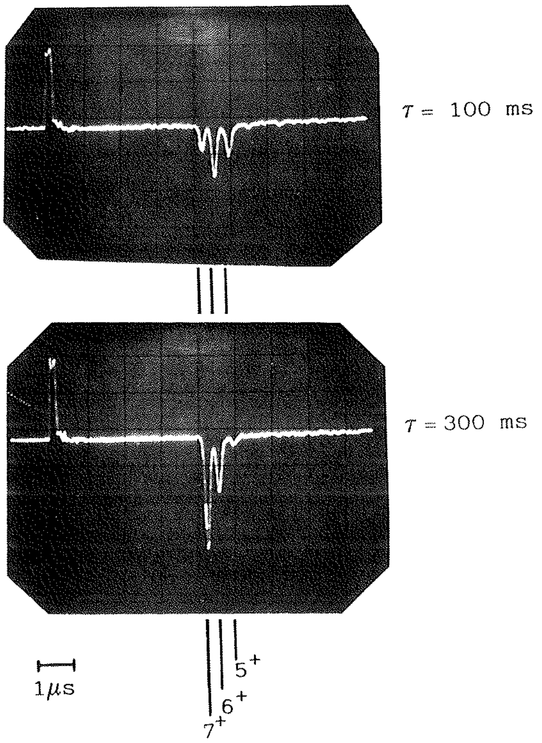

Fig.7a - Distribution of charge states obtained for nitrogen with 100 ms and 300 ms confinement times

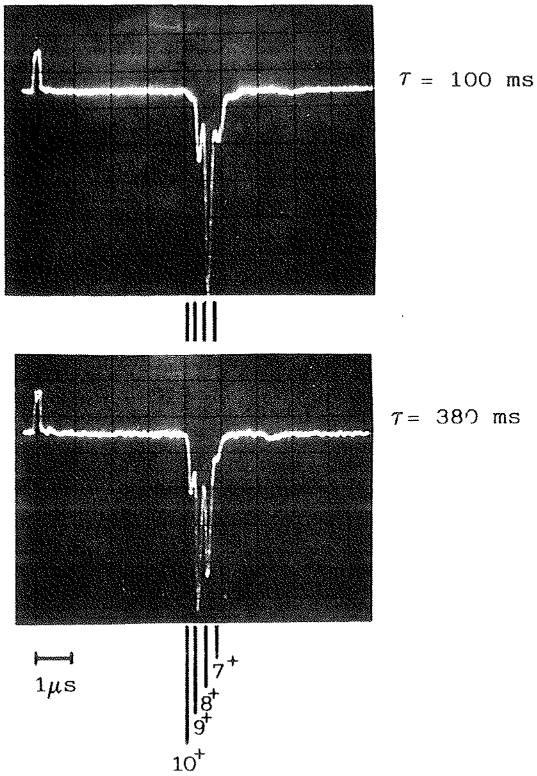

Fig.7b - Distribution of charge states obtained for neon with 100 ms and 380 ms confinement times

References

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