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# DEVELOPMENTS OF THE CRYEBIS GENERATION AT ORSAY

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## Abstract

CRYEBIS 2 is completed.The project is described. Main features are: 50 keV- 3.5 A decelerated electron beam, 5 T- 1.6 m long superconducting solenoid at 2.3°K. The gun to reach $10^4$ A.cm$^{-2}$ has been tested, and SILFEC 3, a smaller scale model of CRYEBIS 2, has been extensively used with a CW electron beam and joined cycles up to 6 kV-1 A. The deceleration of electrons is reliable ( from 10 keV to 1.8 keV ) and the produc--tion of atoms of metal species by means of a laser has been tested.

## Introduction

CRYEBIS 2 is an EBIS devoted to atomic physics experiments and source development. The main goals are to produce fully stripped ions up to $Xe^{54+}$ and He-like ions up to $U^{90+}$ with a particle intensity greater than $10^9$ per second.Source development include control of very high density electron beams ( E.B. ) attained by super compression [1] , production of metal ions, new ways of injection, new methods of collection. To fulfil atomic physics requirements, a continuous E.B. of 50 keV-3.5A and a current density of $10^4$ A.cm$^{-2}$ must be focused and collected, it must also be possible to bias the source and its control systems up to 50 kV. Extensive preliminary experiments are being made on the gun test bench and SILFEC 3, a smaller scale model of CRYEBIS 2 , to avoid numerous technical adjustments on the main device. CRYEBIS 2 is duplicated for the Research Institute of Physics in Stockholm, Sweden (Swedish Ion Source project ).

## Description of the source

The general design resembles that of KRYON 2 [2] . Considering that the flexibility of the CRYEBIS 1 ver--sion [3] with two separated cryostats is couterbalanced by a too much high LHe consumption for a laboratory device, we have turned back to a compact superconducting solenoid with a cold bore (0.1m inner diameter,1.6m long, 5T ).The temperature of the LHe cryostat is lowe--red to 2.3°K by pumping the bath for better hydrogen cryosorption and a cryogenerator is used to cool the two radiation shields of the vessel (20°K-80°K ).The LHe consumption with the E.B. in operation is expected to be lower than 2 ℓ per hour (with self-sustained coil current ). The magnetic shield is 8 cm thick made of XC6 steel with side flanges made of Armco.The drift tubes are located within the cold bore: a U-shaped Aluminium structure contains the 32 stainless steel tubes connected to an external potential distributer. The other major differences with respect to CRYEBIS 1 concern the guns and the collection system.The final goal ( 50keV-3.5A )will be reached in successive steps and by the use of several guns ( Table 1 ), all of the external type. A complex mechanism allows adjustment of the gun cathode in any direction versus the anode and the entire electron gun is movable along the source axis.

| GUNS | NC1 | PANC1 | FRECH1 | NC4 | PANC4 | NC3 |
|---|---|---|---|---|---|---|
| Max voltage (kV) | 10 | 30 | 10 | 40 | 50 | 10 |
| Max intensity (A) | 2 | 2 | 2 | 3.5 | 0.5 | 2 |
| Max average density (A.cm$^{-2}$) | $10^3$ | $2.10^3$ | $3.10^3$ | $10^4$ | $10^3$ | $10^4$ |
| Cathode diameter (mm ) | 36 | 36 | 18 | 12.7 | 12.7 | 18 |

Table 1 - Gun characteristics at 5T.

The cathode may be retracted behind a gate valve to preserve it from the air entrances.The collection is assumed by a decelerating monostage collector [4] (Fig 1) able to dissipate 20 kW , making use of the hypervapo--tron effect: demineralized cooling water is evaporated at the hot surface and subsequently condensed by a fast cylindrical laminar flow.The injection of the material to be ionized is not yet optimized and several possible methods will be successively tested on the two sources (SIS and CRYEBIS) during the first weeks of experiments: for the gases -the"traffic controller system" sugges--ted by Donets [5] .

-a pulsed valve making use of the Lorentz force close to the middle drift tube.

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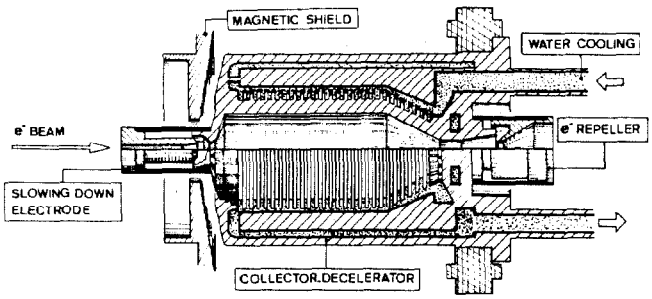


Fig.1. Collector of CRYEBIS 2.

-laser beam stimulated desorption of a condensate.
-evaporation by means of an infrared laser.
-vacuum spark evaporation.
-as suggested by Becker [6], an ion beam-target interaction.
-a transverse focused jet [7].

The source is outlined in Fig. 2 ( a LHe refrigera-tor system is connected on-line with the SIS and thus the chimney is somewhat different).On Fig.3 the experi-mental area with the source platform is shown. All the E.B. focusing electrodes are referenced to the cathode voltage and thus most of the power supplies are located on a second insulated platform biased at the cathode potential.The ion species will be selected either by a 4m long time of flight spectrometer or by a magnetic analyzer.

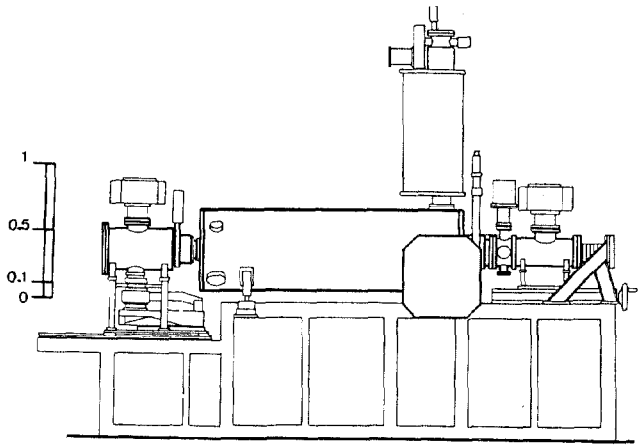


Fig. 2.Schematic view of the ion source.

## Preliminary experimental results

The final figures of merit of the source strongly depend on the feasibility of a long containment time and E.B. deceleration.We have used the gun test stand to try out the monostage collecting geometry:

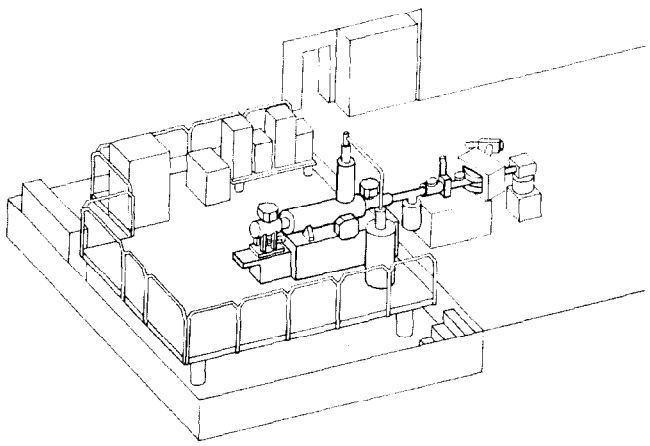

Fig. 3. Layout of the CRYEBIS experimental area.

a CW 10 keV-2A E.B. has been decelerated to 1.8 keV and collected. The power consumption of the 10 kV power supply is less than 100W and more than a factor 5 is gained on the dissipated power in agreement with computations. We hope to collect only 20 kW for an 175 kVA reactive E.B. power. The test stand has been impro-ved to make possible beam profile measurements and on-line Abel conversions with a HP 85 Hewlett-Packard calculator.The FRECH 1 gun [8] exhibits a core current-density of 1600 $A\text{-}cm^{-2}$ at 0.3 T which means more than $10^4$ $A\text{-}cm^{-2}$ at 5T including the thermal effects calcula-ted from Pierce-Walker[9]. The NC3 gun with better lami-narity and homogeneous cathode loading is being tested and will provide $1.10^4$ $A.cm^{-2}$.

The NC1 gun and the monostage collector have been tested on SILFEC 3. In this small EBIS ( 3 classical coils, 0.5T, inner cryopanel at 20°K ) a magnetic homo-geneizer is incorporated [10]. A CW 6keV-1A E.B. decele-rated to 1.2 keV has been successfully used producing ions up to $C^{6+}$,$N^{7+}$,$O^{8+}$ and $A^{16+}$. The basic source pressure is not affected by the deceleration and the electron backstreaming is thus low enough to prevent desorption from the drift tubes even at low temperatures. We have used NC1 with post-acceleration ( PANC1 ) from 2 to 6 kV.

The launching conditions ,as a result , are improved and the interception with the source electrodes is lower than 1 µA for a 0.16A primary beam. With injection of Argon, containment times up to 2 seconds are then possible. Post-acceleration works so well that the better part of our guns will be used with this arrangement to get 50 kV without too much E.B. power.

Evaporation of atoms of the metals by laser inter-
-action is working on another test stand before to be experimented on SILFEC 3 . The position of the lens may be optimized by measuring the electron flux emitted from the target which is maximum in the focal plane. The reflected power is then minimized but still high enough to heat any nearby surface . The injection tube ( at 20°K ) should thus rather be a grid for lower inter-
-ception. At 8 J , 40Hz , the temperature of the target may reach 200°C .

## Expected characteristics

The expected yield in the cyclotron mode , i.e. with joined source cycles is shown on Fig. 4 . For an expulsion time up to 5 msec , the feasibility of which is now perfectly established , a duty-cycle within the range 10-50 % is realistic. The anomalous E.B. compres-
-sion with ions now observed several times [1,11] , will probably enhance these yields.

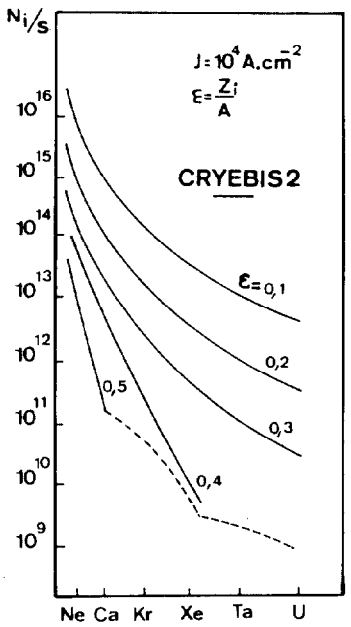


Fig . 4 . CRYEBIS 2 yields in the cyclotron mode.

The source now completed ( superconducting solenoid and shorting bridge tested at 6 T ) would deliver ions up to $A^{18+}$ in September 83 , up to $Xe^{54+}$ in Septem-
-ber 84 and up to $U^{90+}$ in September 85 . For the SIS E.B. is foreseen in December 83 .

Salaries excluded , the total cost of CRYEBIS 2 and the experimental area is 2.4 MFF . " Manpower " used corresponds to 40 persons-year .

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