THE 3 PREINJECTORS OF MIMAS FOR HEAVY IONS POLARIZED AND UNPOLARIZED IONS J.Faure, JL.Lemaire, R.Vlenet

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STATUS REPORT ON DIONÉ

- Saturne Heavy Ions Ebis -

Introduction

Dione has been installed on the 25 kV platform in january 1987 in order to inject into the 187.5 keV/Amu RFQ MIMAS preinjector. The first injection test occured in july and heavy ion nuclear physic experiments started up in october.

The performances obtained at the exit of the source are given in the following table together with the accelerated beam intensity in the synchrotron.

The emittance is $2 \ 10^{-7}$ m rd (normalised value).

loa species	Source exit (charges)	Number of injected pulses	Intensity in SATURNE
N ⁷⁺	7 10 ⁹		
C. ₆₊	4 10 ⁹	4	4 10 ⁹
Ne ¹⁰⁺	10 9	4	10 ⁹
Ar ¹⁰⁺ Ar ¹⁷⁺ Ar ¹⁸⁺	10 ⁹ 610 ⁸ 210 ⁸	Э	10 ⁹
Kr ²⁸⁺	4 10 ⁸		

Description of the source

This type of source has been described many times before[1, 2]. The basic process consists in ions stripping by electrons in the range of 10 Kev energy.

The ions are trapped radially by the electron beam self field and longitudinally by the potential distribution given by biased electrodes . Presently ,in DIONE, a 0.36 Amp. 10 keV electron beam is compressed in a 5 Ts magnetic field to achieve a high electron density for the stripping process. The performances are limitated by the maximum electronic density we can reach.We have measured a maximum of 1500 A/cm² instead of the 5000 A/cm² expected.

In the other existing EBIS the first ionisation is made on gas molecules.During EBIS developments in SACLAY we have demonstrated [3] that it is possible to inject ions from conventional source into the electron beam through the collector.This process has many adventages:

- one can ionise any kind of species provided a low charge source is available.
- * the ions quantity is limitated to the exact necessary amount.
- * experimental investigations are made easier.
- * no vacuum problems and perfect stabilities of the performances.

Theoritical investigations

Many theories on the basis of plasma considerations pointed out resonance possibilities.But the approximations involved make very difficult the exploitation of the results. Nevertheless the density distribution of the primary electron beam seemed to be a very important paameter.

Therefore we decided to investigate in this direction. We have calculated ions behaviour in an electron beam taking into account the electromagnetic and space charge forces (no collective effects as in a plasma).

We found out that a gaussian distribution as measured on guns is responsable of two phenomenas

- 1) electron beam density decrease (Fig.1)
- 2) extracted ions emittance increase

The measured beam emittance was in very good agreement with the predicted one by these calculations as one can see on the figure 2.

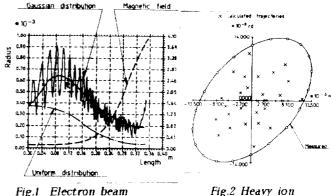


Fig.1 Electron Deam Compression

beam emittance

As a conclusion, this modelisation of the EBIS is very satisfactory and we decided to make all the possible effort in the density improvement direction:

EBIS improvement program

- 1)- New code for electron gun calculation
- New test bench for electron beam density distribution measurement.

In the near futur a new electron gun will be tested and we hope to improve performances :

- * at least a factor 2 from electron intensity increase
- another factor from density distribution improvement

References

- [1] Dioné a new Ebis under construction at Saturne HIA Oxford 2-5 July 1984
- [2] Status Report on Dioné 3rd Int.Conf. Ebis Workshop - 1985 - Cornell University, Ithaca, N.Y.
- [3] External injection into Cryebis NIM.219(1984)449-455

STATUS REPORT ON HYPERION

- Polarized Proton and Deuteron Source -

This equipment is dedicated to produce polarized protons and deuterons. The source has been reassembled from an used atomic jet generator (bottle sextupole magnet and RF transitions) which was running DC at the Saclay cyclotron yielding a beam current of 3 μ A. The new source is now installed in a 400 kV high voltage terminal. It consists of (Fig 1).

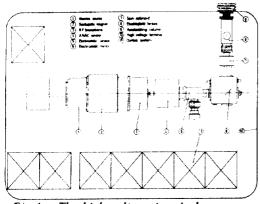


Fig.1 : The high voltage terminal

- An atomic source (ground state type) jet and dissociator operating at 17 MHz,
- a conventionnal sextupole magnet. longitudinaly tapered,
- two sets of RF transitions 2 RF transitions for protons (16.2 MHz and 1430 MHz) giving the required polarisation states, replaced by 3RF transitions in the case of deuterons (10.8 MHz, 343 MHz and 415 MHz) giving the whole polarisation states.
- an ionizer supplied by ANAC from which the ions are extracted at 16KV.
- an electrostatic beam transport line made of a set of Einzel lenses. Before beeing accelerated at 400 kV, the beam is deflected by 90° using an electrostatic deflector and the polarisation vector is set vertically to the axis of the beam by an appriopriate solenoid magnet.

Since 1979, [1] time at which the source has been connected to the Saturne synchrotron the performances were widely improved.

First step :

- Both gas inlet and RF were pulsed instead of beeing continuous.
- the piezo electric valve is very closed to the bottle
- a self exciting oscillator allows a better tuning of the RF discharge
- the skimmer location and shape were optimized to get an intense atomic jet on the axis
- better pumping was provided by using turbomolecular pumps (1500 1/s) followed by boosters (150 1/s) in order to deal with gas scattering effects.

Second step :

- a cooling system of the nozzle using the 2 stages of a closed cycle helium refrigerator leading to an optimum value of the temperature of 90K was installed.
- consequently to the decreasing of the atom velocities, the sextupole magnet aperture was enlarged.

Third step

- total rebuilt of the ionizer allowing a perfect alignment between the coaxial magnetic and electrostatic fields leading to a better stability of the ionizer.

- pulsation of the electron extraction electrode E1.

Atomic jet parameters

- the atomic beam pulse duration is 2 ms, setted by the dissociation RF pulse and can be varied.
- the atomic jet has been optimized in order to achieve the highest atomic beam density in the ionizer, that should be varying like $T^{-3/2}$. This dependence comes from the dwell time of the atoms in the ionizing region like $T^{-1/2}$ and from the acceptance of the sextupole magnet like T^{-1} . This gives the gain that we should obtain by cooling down from room temperature to the lowest attainable temperature given by the cooling device.
- in fact the gain does not follow this law.

There is competition between different parameters in the accomodator where recombination effects take place. Even by choosing low recombination surface material (that are presently golden coated copper at the optimum temperature), volume recombinations seem to limit presently our atomic density and our optimum temperature stands at 90K [2].

The velocity of the atoms coming out of the nozzle can be measured by a time of flight method. The atomic jet is chopped by a rotating chopper (disk or blade) and the mean velocity corresponding to the optimum temperature of 90K is 2000 m/s, while the Mach number is closed to 7.

Ion beam parameters

Beam Current

The atoms are ionized when passing coaxialy through a reflex ionizer (Fig.2). Electrons are drawn off a tantalum filament by an electrode E_1 which is at potential of 1.8kV relative to the filament : the filament of circular shape is heated to 1900°C by a direct current. The E_1 voltage is pulsed and this pulse width of 1 ms defines the ionic pulse duration, acting as a beam chopper. The ions are extracted and travel down through a set of electrostatic focusing electrodes, to a Faraday cup.

The present performance is 500 μ A (Fig.3). Before beeing accelerated to its final energy of 386kV the beam goes accross a 90° eletrostatic deflector of which electrodes are made of tantalum weaven wires having a transparency of 90%.

Beam emittance

The emittance is measured after the beam has been accelerated at 386 keV. A 51° bending magnet selects the H^+ or D^+ lons and the measurement is performed by using a gradient method (focusing strength of a quadrupole is varied ahead of a profile monitor and corresponding beam profiles are recorded).

Both horizontal and vertical emittances can be obtained and typical results are shown on Fig.4.

In both planes we get $\varepsilon = 130.10^{-6}$ m.rd leading to normalized emittances ($\varepsilon_{x,z}$) = 10⁻⁵ m.rd. The results are also used to match the beam to the transport line.

Energy spread

We do have the possibility of measuring the energy spread of the beam further down the beam line by using another bending magnet, a slit and a profile monitor, as spectrometer. Fig.5 shows a typical result giving the total energy spread $\Delta W = 3.2$ KeV for the optimum set up. of the ionizer.

Polarization of the beam

For deuterons, polarization can be measured at 386 KeV but for protons one has to accelerate the beam to 500 MeV through the 2 synchrotrons Mimas and Saturne. In both cases the polarization is better than 90%.

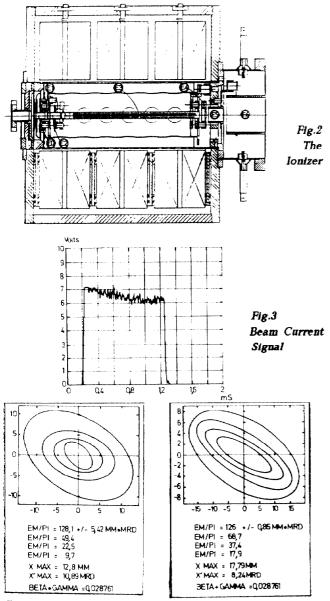
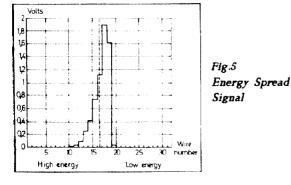


Fig.4a : Horizontal Emittance - Fig.4b : Vertical Emittance



References

- [1] Saturne linac performances in 2βλ mode for polarized protons acceleration - Proc.1981 Linac Conf.Santa Fé
- [2] The Saturne polarized particle source Int.Workshop on polarized sources and targets - Montana 1986

STATUS REPORT ON AMALTHEE - Unpolarized ions -

This 750 keV pressurized terminal has been put into operation in 1968.[1].

Formerly designed to produce 100 mA of protons per second at 750 keV with a pulse duration of 200 μ s and a normalized emittance of 2.10-6 m.rd it is still used and provides proton, deuteron and helium beams of high intensity for physics.

The source which sits in the pressurized terminal is a well known duoplasmatron source : life time of the cathod exceeds 6 months. The role of the expansion plasma cup, golden coated, is important to reach the emittance requirements. The extraction voltage of 50 kV has a Pierce geometry, followed by electrostatic focusing having a accel-decel configuration of 150 kV-50 kV. Then the beam is accelerated to its final energy through

an accelerating column of 15 kV/cm field gradient.

The gas pressurized technic is well controlled. We use a mixture of 25% CO_2 and 75% N_2 very less expensive has the same properties.

We have to notice that by installing in the same vessel the Cockroft-Walton generator and the focusing accelerating column, we succeeded to build a much compact preinjector than an open air one.

The bouncer consists of a electrode surrounding both source and power supplies sitting at the high voltage. All the parts beeing housed in the vessel.

Pumping is provided by a mercury vapor diffusion pump of 1800 l/s. The performances obtained at the exit of the preinjector are given in the following table together with the accelerated beam intensity in the synchrotron.

lona	Beam Current (mA)	Pulse Duration (gs)	Normalized Emittance x 10 ⁻⁶ m.rd	Acceler Voltage (kV) cha	
Р	40	450	2	750	1.7 10 ¹²
d	25	450	0.8	375	8 10 ¹¹
$\frac{3}{2}H^+$	15	450	О.В	562.5	2.5 t0 ¹¹
4 H ⁺ 2 H ⁺	16	330	1.5	750	3 10 ¹¹

References

