A NEW BEAM CURRENT MONITOR FOR THE MIMAS STORAGE RING

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Abstract :
In connection with the acceleration of heavy ions, a new sensitive beam current transformer has been developed for the MIMAS storage ring. It can withstand the baking of the vacuum chamber at 300°C and the associated electronics allows measurements during the injection and the acceleration of the beam. Signals provided by weak beams (600 nA) of krypton 30+ have been observed without averaging.

1 - INTRODUCTION

For its commissioning in 1987, MIMAS was provided with a low sensitivity beam transformer (100 mv/A) ; this commercial device could not be used with weak beams and especially during the injection of heavy ion beams. We have now replaced it by a much more sensitive one ; moreover, a new electronics has been developed, which can be used with all the beams and at any time during the injection and the acceleration.

2 - DETECTOR DESIGN

Specific problems arose during the development of the transformer :

2.1. In order to preserve the high vacuum of MIMAS and because of the expansion of the beam in the chamber during the injection and the extraction, it was not possible to install the transformer inside the vacuum chamber as had been done in the vicinity of the ion source DIONÉ, thus avoiding a ceramic break [1].

Because of the large diameter (290 mm) of the chamber, the realization of the insulating ring has caused many problems [2] which delayed the installation of the transformer.

2.2. The magnetic circuit had to be removable without unsoldering an element of the beam pipe.

2.3. The baking at 300°C involved a thermal isolation of the magnetic core in order to keep its temperature below 80°C ; above this temperature, the amorphous material 6025 F is damaged.

These conditions led us to use large diameter magnetic cores (ext.425 mm, int.365 mm, length 25 mm).

2.4. The current delivered by the secondary is given by :

$$I_S = \frac{I_B}{N} \quad I_B = \text{Beam Intensity} \qquad (1)$$

The turn number N on the secondary wires must be low (we have choosen N = 10) for the detection of weak beams.

On the other hand, the secondary inductance L_S must be as great as possible to allow the transmission of low frequencies.

$$L_S = \frac{N^2 \mu h}{2\pi} \cdot \frac{De - Di}{De + Di} \qquad (2)$$

h = total length of the magnetic toroid.
De and Di = int.and ext. diameters of the toroid.

The low value of N has been compensated by using two cores of Vitrovac 6025 F because of the high permeability of this material.

2.5. Usual noise problems have also been encountered ; their effects have been minimized by using three shields (two μ-metal and one copper shields).

The general lay-out of the transformer is shown on photo 1 and figure 1.

Compressed mineral wool provides the thermal isolation ; this low cost material can be lathe worked, scalpel cut, allowing an easy mounting of its different parts which can be stuck together. The shields must be removed during the baking and a small flow of compressed air is added to the thermal isolation [3].

A rubber ribbon has been mounted between the cores and the mineral wool as a vibration isolator ; but it has been established that the Vitrovac 6025 F is not so sensitive as Ultraperm.

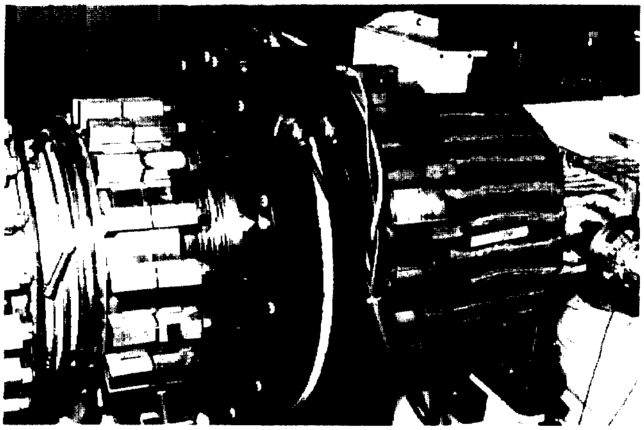
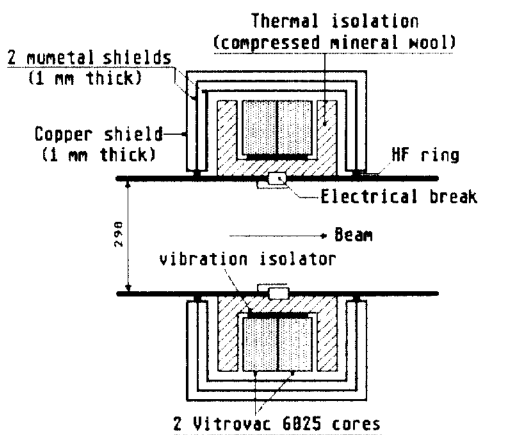


Photo 1



(Ext.diam : 425 mm Int.Diam : 365 mm Length : 26,5 mm)

***Figure 1* - General transformer Lay-out**

3 - THE ELECTRONICS

The scheme of the electronics is given in Figure 2 ; it fulfils two requirements :

3.1. A large bandwidth to transmit the great variety of signals produced by all the MIMAS beams :

- low frequency signals during the injection ; the lowest frequency corresponds to a ramp of 1 ms duration with a repetition rate of about 1 sec.
- high frequency signals during the acceleration, with a repetition frequency which ranges between 162 kHz and 2.5 MHz.

3.2. A large dynamics to cover the intensity range ; the peak values of the intensity stretch from hundreds of nA (injection of krypton) to more than 500 mA (acceleration of light ions).

For this purpose, computer switched gains are located in the preamplifier and the amplifier units ; nine different gains can be selected, allowing current to voltage conversion factors between 5V/A and 10^5V/A. Two filters (high pass and low pass) can be operated in order to keep only the necessary bandwidth so as to improve the signal to noise ratio.

Special attention has been given to noise capture. The preamplifier is closely connected with the secondary of the transformer and shielded with μ-metal; the coaxial cable between the preamplifier and the amplifier (3 meters length) is also shielded with μ-metal.

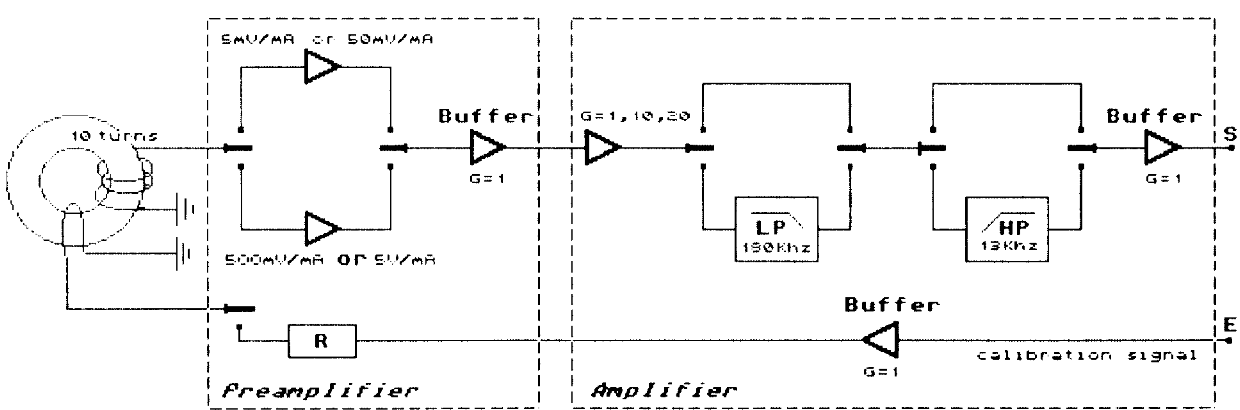


***Figure 2* - Beam transformer electronics**

4 - RESULTS

The signals of the figures 3, 4, 5, 6 have been observed during the adjustments and operation of MIMAS with high intensity light ion beams and with very weak krypton beams. These signals have been recorded without averaging.

The authors are indebted to J.Faure and M.Soucaze for the realization of the ceramic break, to N.Rouvière and her Group who solved the thermal isolation problems and to J.P.Pénicaud for his help during the design of the magnetic toroid.

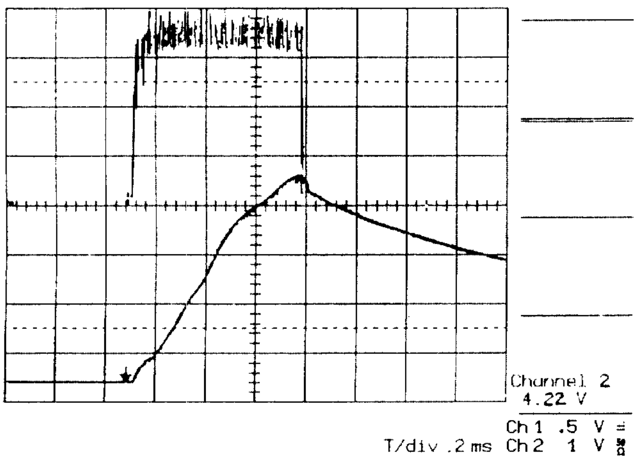


***Figure 3* Injection of a high intensity (80 mA peak) light ion beam.**
The upper signal is recorded on a Faraday cup in the injection line.

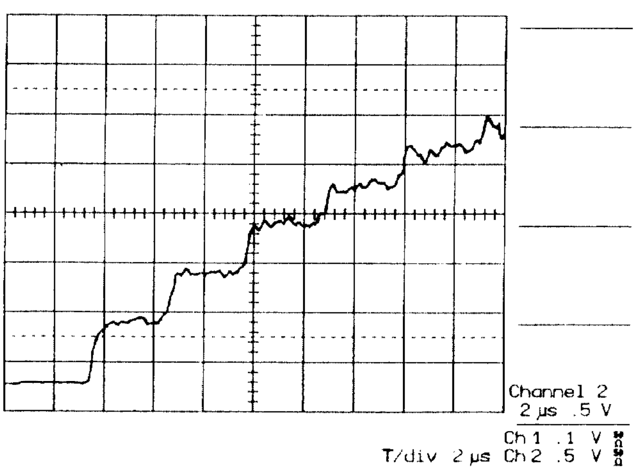


***Figure 4* : Intensity increase during the injection of a high intensity beam**
(increase = 1 mA/turn).

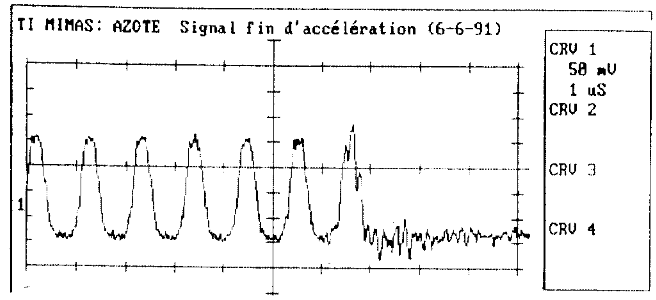


***Figure 5* : The last acceleration turns of a N^{7+} beam (peak intensity : 400 μA).**

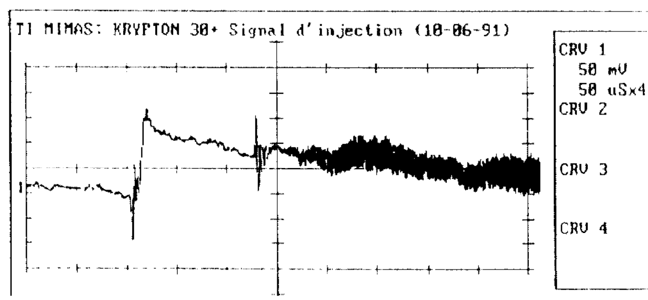


***Figure 6* : Injection of a krypton 30^{+} beam (peak intensity : 600 nA).**

5 - REFERENCES

[1] L.Degueurce "Beam diagnostics for the Ebis ion source at Saturne", NIM, A 260, pp 538-542, 1987

[2] B.Gastineau - M.Soucaze "Coupure électrique du T.I." Ref : LNS/SSGD 91/74

[3] N.Rouvière "Isolation thermique du T.I." Ref : LNS/SSGD 92/98