THE MIMAS AND SATURNE KICKER MAGNET SYSTEMS

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Abstract

This paper describes the fast pulsed magnet systems which have been made for the new injector of SATURNE, the MIMAS synchrotron.

Introduction

The transfer of particles (protons through particles q/A = 0.3) from MIMAS into SATURNE needs :

- in MIMAS, a fast extraction system which will deflect the beam into the transfer channel after acceleration,

- in SATURNE, a fast injection system which must bring the beam from its transfer trajectory into the closed orbit of the machine.

The magnets are inside the accelerator vacuum chamber.

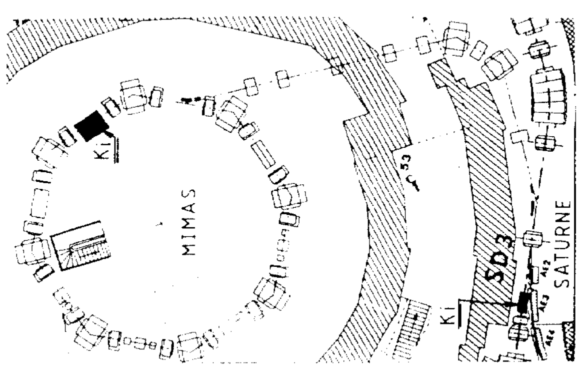

Fig. 1 : layout of the transfer channel

Specifications

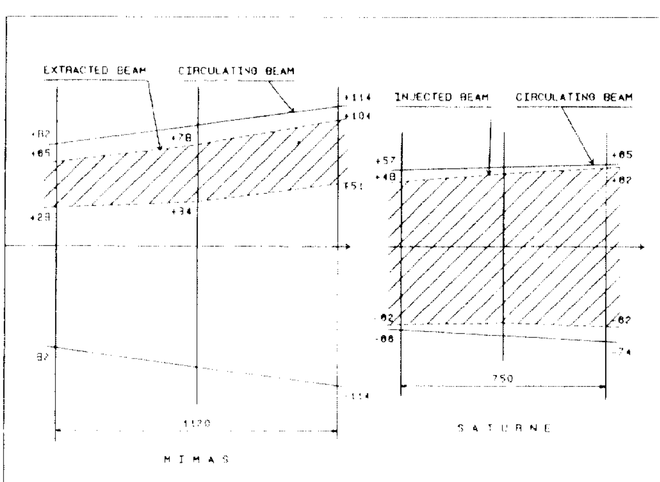

Fig. 2 BEAM RADIAL SIZES

table n° 1 : specifications	MIMAS	SATURNE
magnetic radius of particles	1 T.m	1 T.m
deflection angle	22.73 mrad	19.89 mrad
pulse repetition time	1 s	1 s
kick rise time at 1 %	200 ns	-
kick fall time at 1 %	-	950 ns
flat top duration	550 ns	550 ns
flat top ripple	1 %	1 %

System description

1°) Magnets

MIMAS : the injected beam is wider then the extracted beam ; a C-type magnet is adopted and the placement of the return conductor has been chosen to minimize the inductance of the circuit and maximise the good field region.

SATURNE : the injected beam and the circulating beam have about the same dimensions ; a window frame magnet has been chose with a 4 mm gap between conductor and ferrite for insulation. However the field is slightly non uniform near the conductors. This can be cured by making a notch to the ferrite.

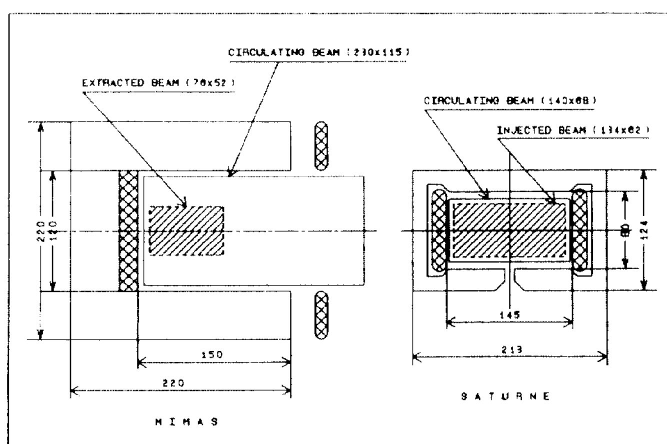

Fig. 3 : CROSS SECTIONNAL VIEWS

A Ni-Zn ferrite offering high saturation induction, high resistivity and low coercitive force has been used (8C11 Philips). This material is especially suitable for application under high vacuum.

To determine the magnetic field into the gap and in the ferrite we use the PANDIRA's code. To take in consideration the distribution of current in the conductors which is due to HF, we use the option "imposed potential of conductors" (IPC). In the case of MIMAS kickers, we compare the IPC option with these of "imposed currents of conductors" (ICC) to fix the difference of conductor potentials.

The main characteristics of magnets are displayed the following above tables. Notice that we choice precisely a generator impedance 16.67Ω, because it corresponds to one third of 50Ω and can be obtained by setting 3 cables (50Ω impedance) on parallel.

2°) Particular features of MIMAS magnets

table n° 2 : MIMAS magnets features	
number of modules	3
type	on C, shorted delay line, with 14 cells
aperture (width x height)	150 x 120 mm^2
one module magnet inductance	0.735 μH
magnetic length	1.13 m
cell's capacity	173 pF
impedance	16.67 Ω
maximum field	0.02 T
rise time (1 to 99%)	160 ns
flat top duration ± 1%	550 ns
magnet current	1 950 A
generator voltage	33 kV
gas pressure in vacuum tank	5 10^{-9} P

The MIMAS kicker module is similar in design to this used in CERN's AA ring. In reality, each of the MIMAS magnets is a shorted delay line of 14 cells formed by C cored ferrite, 19 mm thick. The vacuum capacitors are integrated in the ferrite circuits, so there is not discontinuity between impedance of the pulse generator and the magnet's one.

Notice, that a magnet's cells auto-coupling lead to degrade the rise and fall times.

3°) Particular features of SATURNE magnet

table n° 3 : SATURNE magnet features	
number of modules	1
type	window frame, with correcting circuit R-C
aperture (width x height)	145 x 80 mm^2
magnet inductance	1.70 μH
magnetic length	0.748 m
maximum field	0.0266 T
fall time (1 to 99%)	370 ns
flat top duration ± 1%	550 ns
magnet current	1 700 A
generator voltage	28 kV
impedance	16.67 Ω
gas pressure in vacuum tank	1 10^{-7} P

The magnetic circuit of SATURNE's window frame magnet is constitued of ferrite blocks and excited by a monospire current loop. To short-off the rise time of magnet and to assure a pseudo adaptation avoiding a voltage overshoot, we set on parallel to the magnet a correcting circuit R-C (R = 13Ω, C = 1.7 nF).

4°) Generators

It is basicaly a Pulse Forming Network discharging in a mismatched load. This technic allows the pulser to works at approximatively half voltage required for a matched resitively terminate PFN. This resistor body is made of 8 ceramic disks 2 Carbone Lorraine.

The Pulse Forming Network, PFN, (115 m length) and the Transmission Line (75 m length) are constitued of coaxial cable RG 220 U FILOTEX, 50Ω impedance, silicon grease coated.

The connecting plugs, FFB 6Y 450 CHAC 29 and ERA 6Y 451 CHL, are made by Lemo, the insulating pieces are of "torlon" and have a coating of silicone grease (Rhodorsyl type B 431).

The power supply for recharging the PFN is basically a pulsed resonnant system using a step up transformer (ratio : 316) to couple a primary electrolytic capacitor to the PFN via a HV diode. About 6 ms before the kick the PFN's are charged simultaneously. The charging time is 3 ms.

Discontinuity of impedance is imputable to switches, and it causes indesirable reflections perturbing the current waveform after the rise time (for MIMAS) and the fall time (for SATURNE) are over. It's necessary to improve the impedance quality with correcting circuits, but if we do so the switch rise time is degraded :

- main switch : 90Ω + 280 pF
- dump switch : 450 pF.

That's why an adapted resistor and a switch are between the generator and the ground. Besides that allowes to control the flat top time.

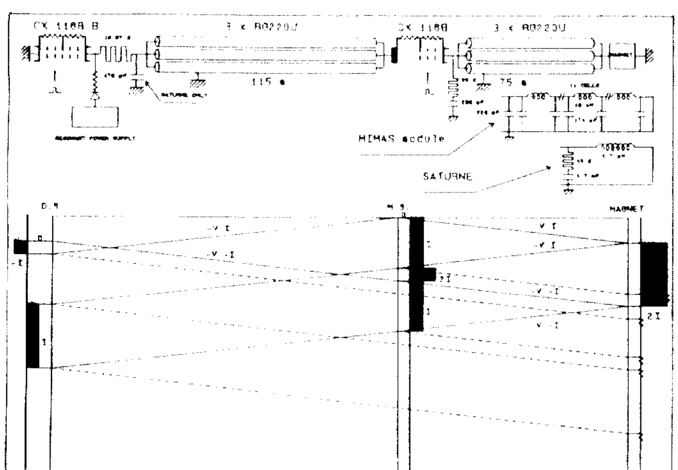

Fig. 4 SYSTEM SCHEMATIC and RAILWAY DIAGRAM

The MIMAS magnet system is design to run exceptionnely with only 2 extremes modules (2950 A). The switch network is studied for thyratrons CX 1168 and CX 1168 B (double ended) EEV, respectivily for the main and dump switches, standing a voltage over 50 kV.

A local microcomputer drives the four systems. The signals are computed with :

- a) a table of constants depending on the particle types,

- b) a top delivered from the main accelerator indicating the transfer starting point.

Results

Up to this day, the kicker system have run for particles from q/A = 1 (which is a case of polarized protons) to q/A = 0.4 (which is a case of Ar^{16+}). The efficiency of global MIMAS-SATURNE transfer was near by 1 in any case. We have good reasons to advance the same results for particles until q/A = 0.3.

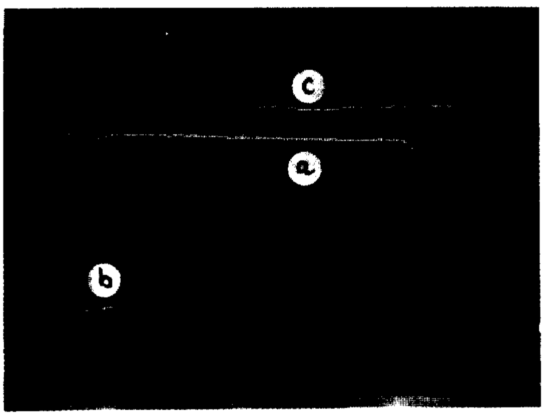

Fig. 5 : MIMAS magnetic field in the three modules

Bm = 0.0201 T
Bm x 5 % /div.
a) flat top : 100 ns/div.
b) beginning of the rise time : 50 ns/div.
c) beginning of the flat top : 50 ns/div.
b) and c) same trigerring

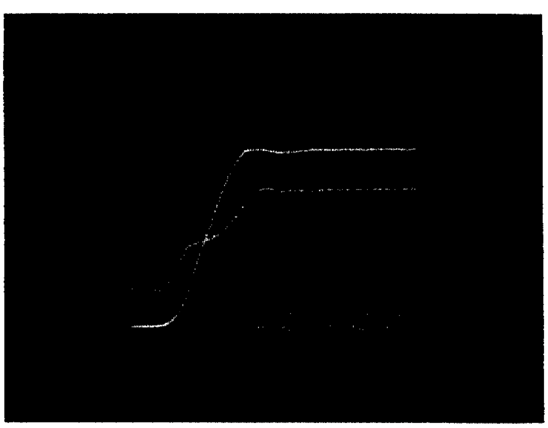

Fig. 6 : MIMAS magnetic field in the three modules and current in one module

The kicker system started to run in march 1987, and since we recorded more then 4.5 millions kicks.

Acknowledgements

Thanks to D.C. Fiander and K.D. Metzmacher for showing us the many CERN realisations and for the full technical particulars and the outlines of preliminary project, they gave us for our study. Thanks also to all technical team which helps us to carry this work to a successfull issue.

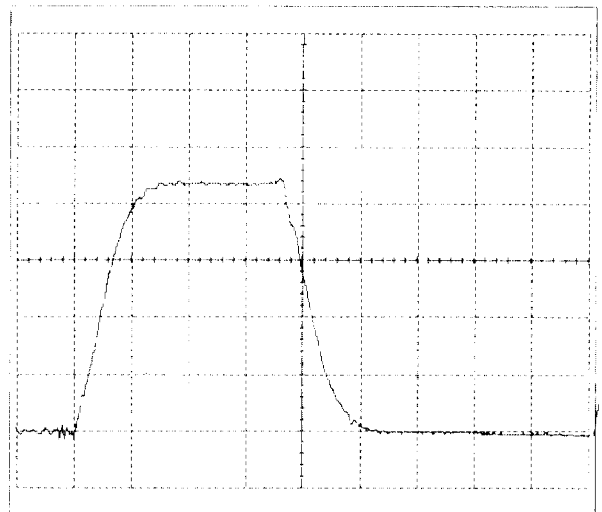

Fig. 7 : SATURNE current in the module

Im = 1710 A
250 ns/div.

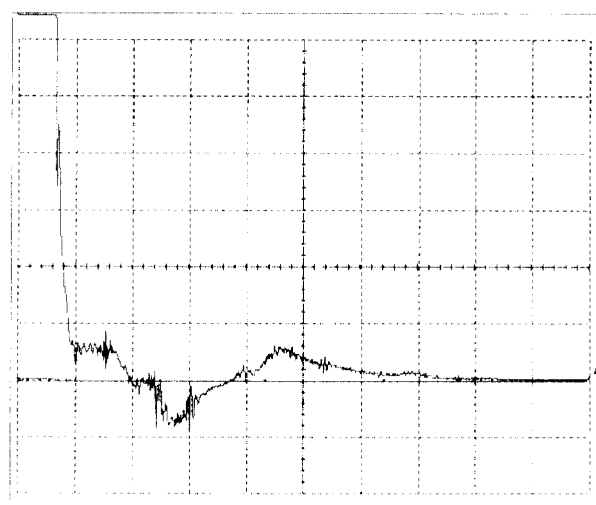

Fig. 8 : SATURNE current after the fall time

Im x 1.1 %/div.
500 ns/div.