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REGULATION OF THE ACCELERATED INTENSITY IN SATURNE

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1. Introduction

Nuclear Physics experiments at SATURNE often require during the same run, a wide range of beam intensities (10^8 up to 10^{12} particles/cycle). These experiments, as well as a good operation of the accelerating R.F. regulation devices (especially at low level) need a constant intensity. In order to avoid frequent adjustments of injection and extraction lines when the beam intensity is to be changed, we always inject, in the same way, a relatively steady strong beam ; so we need to adjust the intensity level once the injection is performed.

Two methods have been used : the first one consists of adding to the phase signal of the R.F. cavities a saw-tooth voltage with amplitude adjusted to the desired correction. The loss of particles in the horizontal plane is a disadvantage ; this leads to a change in the total energy spread of the beam and accordingly in the duration of the slow extraction, carried out by means of a betatron acceleration.

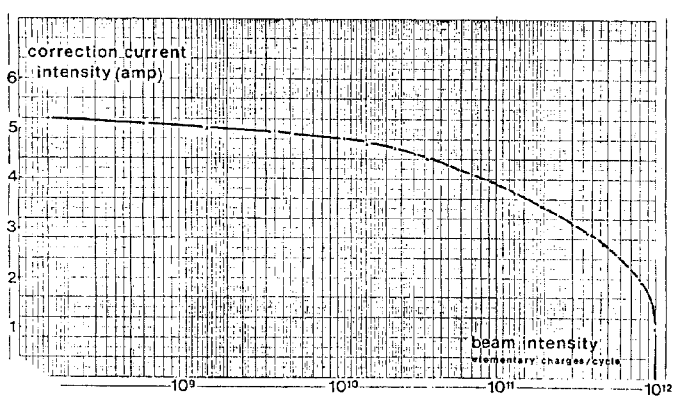
The second way, described here, consists of shifting vertically the beam just after multiturn injection is completed, by a change of the vertical closed orbit leading to a loss on an horizontal plate.

Other devices such as targets with holes or slots inserted in the injection line cannot be easily used and don't produce a sufficient stability.

2. Apparatus description

For the purpose, we use 12 vertical closed orbit correction windings located in the defocusing quadrupoles ($\beta_{z\ max}$) with the help of 12 standard D.C. power-supplies (30 V - 10 A) transformed in pulsed ones. This is done simultaneously and rapidly (within 2 ms) with the same command signal. The effect on the closed orbit is amplified when the main harmonic (h = 4) of the current repartition is close to the tune of the machine ($\nu_z = 3.7$). We get a 12 mm per Ampere displacement.

Experimental curve 1 gives the intensity accelerated versus the winding currents when we inject 2.10^{12} particles in the machine.

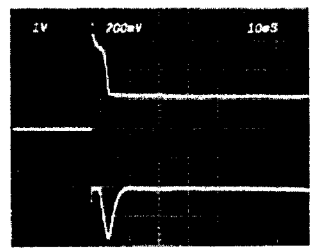


curve 1 - correction currents versus desired circulating beam intensity.

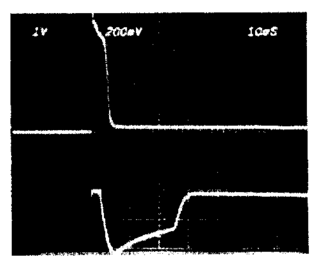
3. Regulation principle

All the power supplies follow a reference signal shaped in rectangular pulse. This begins 1 ms after injection process is finished. The normal vertical closed orbit is not yet perturbed during injection.

When the currents in the windings become close to their maximum, we observe a loss of particles (photo n° 1). In order to regulate the beam circulating intensity we plan a more important loss than the desired level and we stop the reference signal when



this level is reached. Due to the speed of the process and to the fact that energy is growing fast at that time, the end of the loss is immediate (photo n° 2).



Photos 1 and 2 - up : beam intensity signal
down : vertical orbit displacement.

Photo n° 3 shows the regulation efficiency for large changes in injected beam intensities.

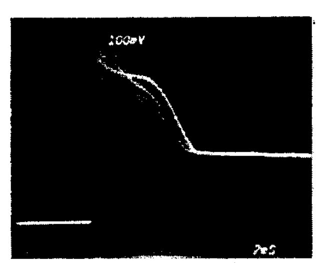


Photo 3 - regulation of the circulating beam intensity.

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We close the servo-loops monitoring the R.F. acceleration just after the perturbation is completed (when the circulating current is well stabilized). This enables us to use the best adapted phase and radius electrode system with gains adjusted to the number of particles.

4. Electronic Regulation System

All the electronics of the regulation system is computer controlled following figure n° 1.

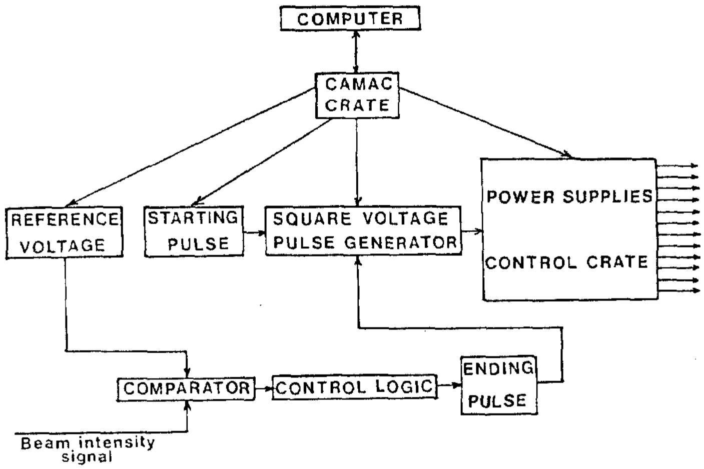

figure 1 - intensity regulation system

5. Influence on the energy spread

The slow extraction duration depends on the total energy spread and it should last as long as possible even for very weak-beams.

The regulation system should not reduce the total energy spread. We have measured this spread with the regulation on and off : for a decrease of intensity up to a factor of ten , we found a decrease of a mere 10 % of the energy spread.

6. Conclusion

This method is now commonly and almost permanently used ; it is very easy to work with, allowing acceleration of constant and very low intensity beams.

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