GANIL HIGH INTENSITY TRANSPORT SAFETY SYSTEM

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Abstract

In order to provide several kilowatt stable ion beams for radioactive ion beam production, the Grand Accélérateur National d'Ions Lourds (GANIL, Figure 1) upgraded several devices [1]. A High Intensity Transport (THI) safety system has also been studied in 1995 and validated in 1998. By monitoring beam losses all along the cyclotrons and lines and shutting down the beam in case of problem, this system allows accelerating and sending onto targets up to 6kW power beams (instead of 400W in standard mode). Beam losses diagnostics, the associated electronics and software will be depicted (principle, location) as well as the tuning method of the machine to reach step by step the needed power.

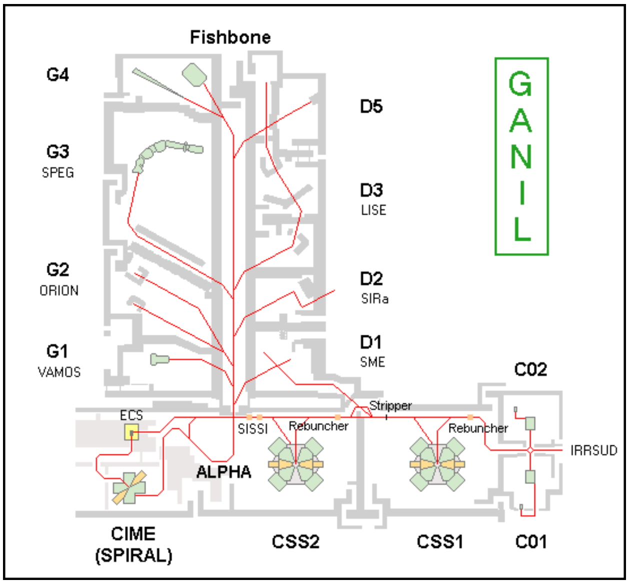


Figure 1 : GANIL layout.

BEAM LOSS DIAGNOSTICS

There are two types of diagnostics to monitor beam losses. First of them are interceptive detectors like diaphragms or cupper plate (Figure 2) that measure the part of beam current lost on them. They are located at the input and output of dipoles as well as at the entrance of the inflectors and deflectors inside the cyclotrons. The location of these diagnostics all along the machine is represented on Figure 3.

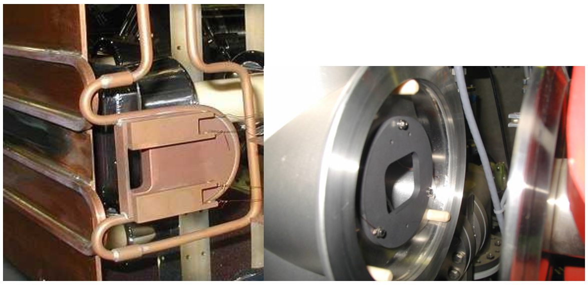


Figure 2 : Beam loss detectors (examples).

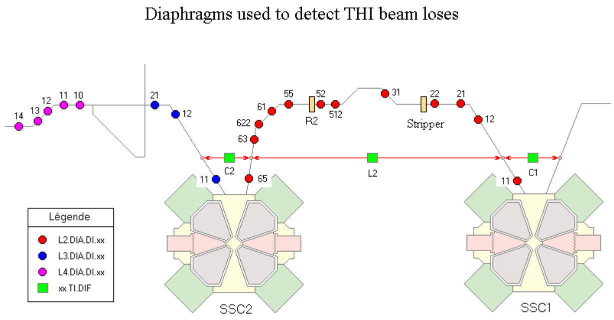

Diaphragms used to detect THI beam loses

Figure 3 : Diaphragm layout.

The second type of diagnostics used to monitor beam losses are alternative current transformer (ACCT, Fig 4). By measuring the beam current at the input and the output of a given section of the machine (cyclotron or beam line), we can determine the transport efficiency and the whole beam losses of the considered section. The differential current transformers layout is given on Figure 5.

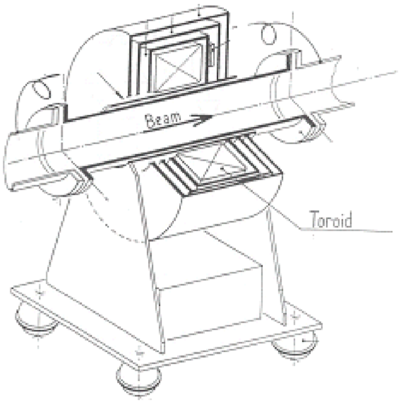


Figure 4: Current transformer.

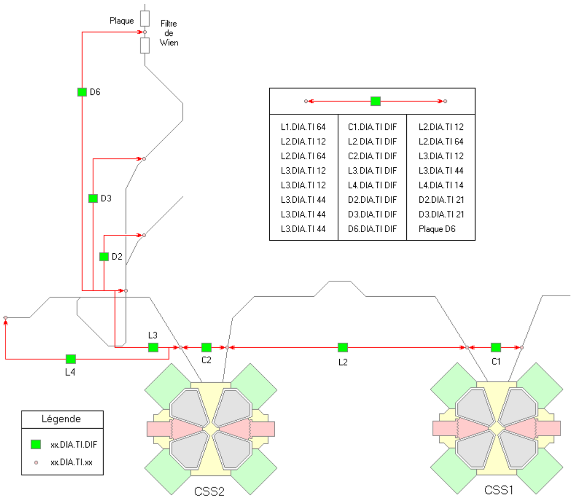


Figure 5 : Differential transformers layout.

The two types of diagnostics are complementary. The diaphragms are dedicated to the protection of a given device (for example the vacuum chamber of a dipole). The differential current transformers have to be considered as a second level barrier that deals with all the losses that are not localised and detected on an interceptive detector (for example, the transport efficiency of a cyclotron may be poor without localised losses on the inflector or deflector).

SAFETY SYSTEM

The general layout of the THI safety system is given on Figure 6

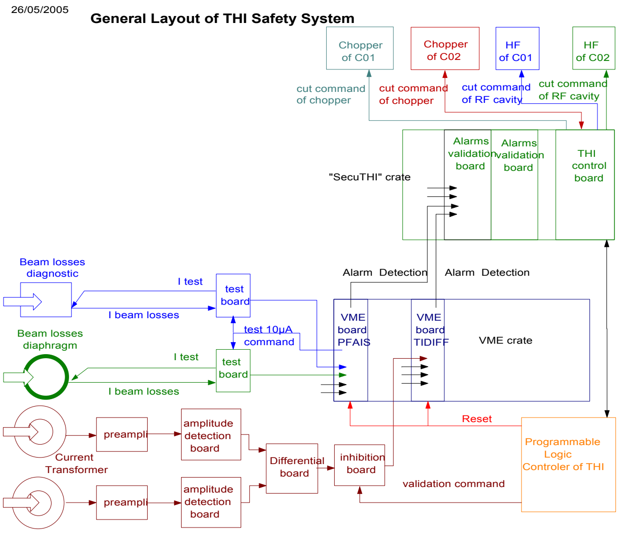


Figure 6 : General layout of THI safety system.

The electrical current returned by interceptive diagnostics is measured on a VME board by logarithmic I/V converters, which generate a voltage proportional to the logarithm of the current. This voltage is digitised, compared to a threshold and numerically converted into a current. Each VME board (PFAIS) can deal with 4 diagnostics. In addition, interceptive beam diagnostics are connected to the test boards which are able to inject a test signal (10μAe) through the diagnostics and filter the return signal. The test process can be remotely controlled by software.

The signals generated by the ACCT are sent through a differential board to a VME board (TIDIFF) which digitises, compares to a threshold and numerically converts to a current.

Each measurement channel of a VME board will generate an alarm signal if the measured current goes over the defined threshold. Depending on the tuning modes, which will be described in the following, the alarm will be taken (or not) into account and the beam intensity will be reduced by setting a chopper on, located in the very low energy line (<1MeV/A), to a security value. The time response is about 20ms. In case of a chopper failure, the RF of the C0 injector is shut down. In order to increase the availability of the beam, the safety system allows up to 3 triggers within a 10 s period before reducing the intensity.

TUNING MODE

Principle

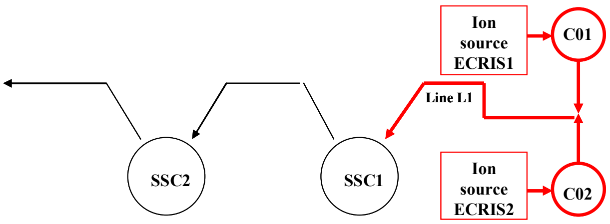
The tuning of the GANIL facility is based on a sequential method, from the ion source to the production target. This sequential tuning is done by keeping the beam power below 400W at every stage of the machine. At this power level, there is no use of monitor beam losses because GANIL was designed for this value.

In order to take into account the space charge effects, it is also important to tune the cyclotrons and the lines at the crest intensity level that corresponds to the max power. That is the reason why we will use a chopper to reduce the mean intensity instead of a pepper pot.

The three following tuning modes have been defined:

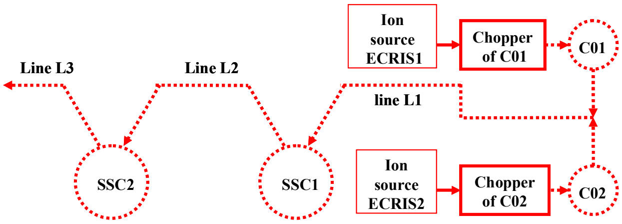
Injector Mode

This mode is used to tune the ion beam for up to the injection of SSC1. The source is tuned to provide the max intensity level needed at the end of the acceleration process. Up to the input of the SSC1, the beam energy is so low that the power cannot exceed 400W even at the max intensity. At the end of this tuning phase, we are sure that the beam intensity available at the input of SSC1 will be high enough.



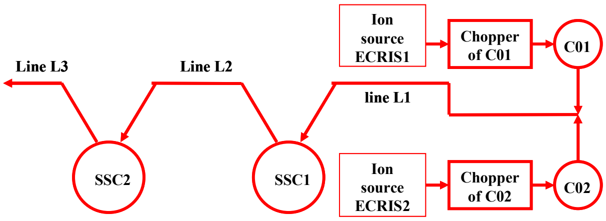
Tuning Mode

By using a chopper to reduce the mean beam intensity (equipment protection) and keeping the crest intensity identical (space charge limitation) a 400W beam can be tuned overall the machine. The beam losses can be monitored to ease the tuning but the THI safety system is still inactive.



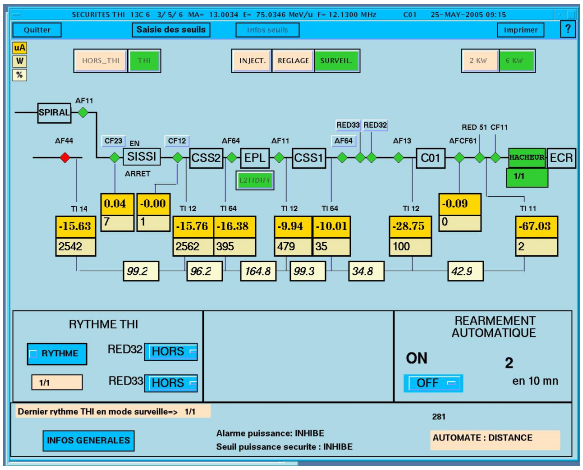
Watching Mode

The high power beam (up to 6kW) is reached in this mode, step by step, by reducing the chopping rate and monitoring the beam losses. The alarm signals generated by the THI safety system are now taken into account and in case of overreaching the beam losses limits, the system automatically switch back to the tuning mode.



REMOTE CONTROL

The Figure 7 is a representation of the high level software available in the control room. Operators may choose the running mode (THI or normal) as well as the tuning mode (injector, tuning or watching). Beam intensity, beam power, cyclotrons and lines transport efficiency are displayed. The chopper rate can also be set by the software to reach step by step the max intensity.



SECURITES THI 13C 6 3/ 5/ 6 MA= 13.0034 E= 75.0346 MeV/u F= 12.1300 MHz C01 25-MAY-2005 09:15

Dernier rythme THI en mode surveille=> 1/1

281

Alarme puissance: INHIBE

Seuil puissance securite : INHIBE

AUTOMATE : DISTANCE

Figure 7 : High level software.

CONCLUSIONS

Thanks to the THI safety system a 26µAe (5kW) for ^{36}Ar at 95MeV/A has been successfully accelerated in 1998. For safety regulation considerations, the power of the beams sent onto production targets of SPIRAL1 facility have been limited to 3kW. The ranges of accelerated beams as well as the RIB produced are presented in [2]. The ten years knowledge and experience of the accelerator team in the high intensity transport issue will be useful to extend the high intensity transport up to the target in the LISE experimental room, which is the room at GANIL dedicated to the fragmentation physics.

REFERENCES

[1] E. Baron et al., High intensity heavy ion beams for exotic nuclei production at GANIL, 16th Int. Conf. On Cyclotrons and their Applications. Michigan 2001

[2] F. Chautard et al., Operation status of high intensity ion beams at GANIL, HIAT 09 (TU07).