THE RADIOLOGICAL SAFETY SYSTEM IN GANIL

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Abstract.- In this report we describe the radiological and access control systems in GANIL. These systems are based on microprocessors use, which are connected to a MITRA 125 computer. The latter centralizes informations coming from the whole radiation-protection system, displays them on a board screen and registers necessary information in order to keep the log-book (a diary).

1. Introduction.- The accelerated and lost ions on the beam lines, injection and ejection systems, slits, beam stop etc... produce by means of nuclear reactions secondaries radiations of varying kinds and energies with a predominance of neutronic radiation. These nuclear reactions create radionuclides in all these materials elements where there has been a loss. In this way, a residual gamma radiation remains when the accelerator is at a halt. The rates of neutron production by interaction of heavy ions with matter are known experimentally for energies not exceeding 10 MeV/A ([1]). Recent theoretical calculations are available for energies of 40 MeV/A and 100 MeV/A. They give the number, angular distribution and the spectrum of neutrons produced ([2,3]). Using this data, it has been possible to calculate the thickness of biological shields to reduce the dose-equivalent rates to as low as possible outside these shields. In any case, of course, these doses will not exceed the legal limits ([4]). Recent data, obtained with the CERN SC external ^{12}C ion beam (86 MeV/A) has confirmed the assumptions ([5,6,7]). Once the heavy shield has been fixed, we must control directly and permanently the dose-equivalent rate in every radiation area by installing a complete detection network and also control access to the prohibited zones by means of safety and access control systems.
We are elaborating on these two points in this paper.

2. Part 1 : Radiation control.- In these areas where we wish to supervise the exposure level, there are monitors which convert into electrical data the gamma and neutron radiation or the gazeous atmospheric contamination. The monitor transmits this information in the form of standardized impulses, to a data processing unit equipped with a microprocessor. This data processing unit calculates the exposure level, compares it to different thresholds and produces a coded alarm. This code is processed by a signalling box placed near the monitor. The data processing unit communicates with the central computer MITRA 125 belonging to the radioprotection service. This computer memorizes the data, displays it on three screens and records it in a logbook.
The layout of radiation control is given on fig 1

A.1. The monitor and its signalling box.

Each monitor comprises a detector appropriate to the radiation to be measured and an electronic unit. Near the monitor, there is a signalling box. The two combined (monitor plus signalling box) form a beacon. The latter is fitted on a trolley (the location of beam loss can be changed later on and the experimental areas modified) and the beacon and data processing unit are connected by means of a cable through a multidirectional connecting box. The installation will thus contain 104 measuring circuits spread over the different areas between 42 connecting boxes and 76 beacons. Three kinds of beacon are used as follows :

- beacons for neutron radiation control : 41
- beacons for gamma radiation control : 33
- beacons for gazeous atmospheric contamination control : 2

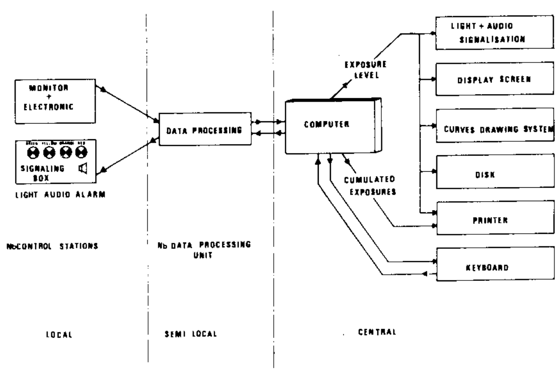

Fig. 1: The layout of radiation control.

The detector's characteristics are as follows :

+ Neutron detector : ^3He- proportionnal counter fitted into a 12.5 cm thick polyethylene sphere. A source made of a Th-w spiral wire and located in the base of the counter ensures a constant check on the functionning of the monitor.

+ Gamma detector : Cylindrical ionization chamber with central electrode, filled with air at atmospheric pressure. The chamber cavity has a tissue-equivalent thickness of 300 mg/cm^2. A ^{137}CS source ensures a constant check on the functionning of the monitor. It is located near the chamber in order to give an average equivalent-dose rate of 50 µrem/h.

+ Atmospheric contamination detector : The monitor commonly called differential ionization chamber is made of two counters of equal volume connected in electrical opposition so that the resultant current measures the volumic activity in the air-flow chamber, the external ambient radiation being compensated by the other chamber. A ^{137}CS source ensures a constant check on the functionning of the monitor.
The electronic unit connected to the detectors consists

of :

+ a B.T. stabilized power supply
+ a H.T. stabilized power supply
+ an amplifier with pulse amplitude discriminator
+ an adjustable pulse divider
+ a pulse shaper.

The electronic unit produces standard pulses of 20V-2µs whose frequency changes according to the equivalent dose rate, each pulse representing a dose-quantum (1µ rem). The signalling box is connected to the monitor to form a beacon. It is fed from the electrical grid by means of the connecting box and feeds the monitor. On the front panel are four lights and an audio-alarm with adjustable frequency and intensity. The warning signs are standardized in accordance with law.

B.1. The data processing unit.
Each monitor is connected by means of the connecting box to a data processing unit equipped with a IM 6100 Intersil microprocessor. The latter processes the pulse emitted by the monitor and sends a coded alarm to the signalling box. The activity level is estimated on the basis of a 3-second period. A coefficient K selected on thumbwheels allows the proximity factor to be taken into account. In the same way, the S_1,S_2,S_3 thresholds corresponding to the different alarm thresholds are also selected on thumbwheels. In order to avoid the alarms being set in motion without due cause, every threshold is equipped with a programmed hysteresis.

The data processing units are grouped in two places of the electronic gallery and in two places in the galleries of the experimental areas. A special rack connect 24 data processing units and the MITRA 125 central computer. Thus every 3 seconds and for every monitor, the following are sent to the MITRA 125.

- Its address
- The risk level
- The states of the thresholds
- Data concerning the state of each monitor and in particular :
  . monitor fault
  . signalling system fault
  . monitor being tested
  . transmission fault.

A pulse generator enables the smooth running both of circuits and connections and of processing programmes to be checked periodically.

C.1. The central computer.
In order to standardize with the computers supervising the functionning of the accelerators, the central computer is a MITRA 125 which ensures, with regard to the radiation control, a certain number of functions of which the mains are given below :

- Reception of the monitor data coming from the data processing unit through the special rack.
- Processing of the states of the thresholds and monitors to maintain the display screens up-to-date and to record the logbooks.
- Evaluation of the accumulated doses for different periods of time.
- Management of the three display screens and of one synoptic.
- Management and processing of the logbooks.
- Management of the control board.
- Recording of all monitors during 24 hours of the exposure level and possibility to display on a memoscope.

The three ADM 3A LEAR SIEGLER display screen are used.

- To display the time and the data and as well any request from the operator.
- To display the synoptic of the risk level for every monitor.

The outline on the screen, in the normal display position, is as follows (in two identical columns)

* Indicator of the access state of the room
* Identification of the monitor
* State of the monitor
* Exposure level in m rem/h
* Graphic representation of exposure level.

If one of the screens fails, the operator can, through the keyboard, concentrate the contents of the three screens on only two screens creating three columns on each screen and suppressing the graphic representation.

The computer records on typewriter any changes in the system and any situations requested by the operator.

The recorded messages are classified into three categories :

a) Messages concerning events and in particular :
. exceeding the thresholds
. monitor fault
. signalization fault
. transmission fault
. intervention concerning the thresholds or K through the thumbwheels.

b) Messages in reply to requests from operator,e.g.
. switching a beacon on or off
. list of the beacons whose exposure level lies between the thresholds S_1, S_2 , etc...
. list of non functionning beacons.

c) Cyclical messages appearing at set times to indicate the beacon's average cumulated levels.

As we have seen, the MITRA 125 acts as a memory, while the processing of monitor data and alarms is carried out on the spot. In the event of the computer breaking down, part of the data remains available locally through the data processing units.

3. Safety devices and control of access to controlled areas in GANIL.-

A. Safety devices.
The main functions of these devices are :

- to ensure that a room does not receive a beam while it is accessible (with or without control of staff movements whether access to the room is restricted or free).
- to check that nobody remains in a room into which a beam is to be passed.
- to refuse access to a room where the beam is passing.

The layout of access controls is given on Fig. 2.

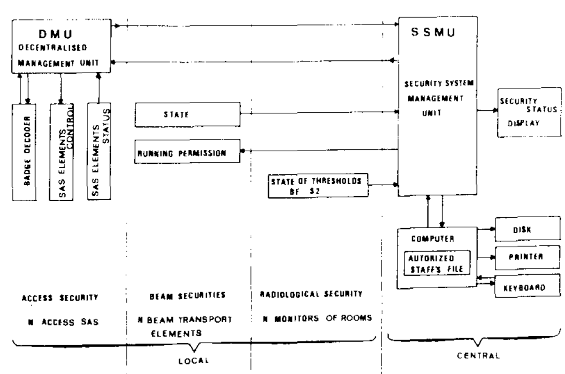

Fig. 2: The layout of access controls.

The safety devices are as follows.

a) the "Beam" safety devices.
In the case of rooms containing injectors, two out of three of the following conditions must be fulfilled:

. No H.F. accelerator electric field
. Electrostatic ejection deflector unconnected
. Ion source switched off

For the others rooms, the two following conditions must be fulfilled :

. the "beamstop" situated up-stream of the room must be in place.

. the deviation magnet which normally sends the beam into the appropriate room and is situated just beyond the "beamstop" must not be connected.

b) The ambient radiological safety devices. We check that, for a room's gamma and neutron detectors, the "smooth running" threshold given by the internal source is reached and that the equivalent-dose rate does not exceed the threshold S_2.

c) the "Access" safety devices .
This concerns : automatic control of staff movement in the controlled access zones.

- checking that the different entry points of a room are closed and locked.
- checking that no room's emergency halt mechanism is on.

For a given room, the all safety conditions are resumed by a state called "Prêt SPR". This state means that all safety conditions are effectively fulfilled. The absence of this state for any room signifies that a fault has occured or that one of the conditions has not been fulfilled.

B. Access Control.
As a general rule, there is only one entry to the different rooms comprising the controlled area. This entry is fitted with an access control system (SCA). However, there are several possible access points to the rooms where the SSC1 and SSC2 accelerators are situated. The SSC1 has 5, 2 of which will be equipped with an access control system; the SSC2 has 3 , only one of which will be equipped with the access control system.
The other entries to these 2 rooms are equipped with conventional doors fitted with electrical closing devices and are only used when free access is permitted. All entries are fitted with light signals indicating the state of access to the room. For safety reasons, all the exits are unobstructed (anti-panic bar). Only these entries equipped with an SCA device are used when the accelerator is operating. A room's SCA prevents entry when access is forbiden(Inviolability) and only allows one person to enter at a time when access is controlled. In this case both the beam security and ambient radiological security conditions must be fulfilled. Staff movement is then checked by means of personal badges.

The actual access takes the form of a chamber 2.5 m long and 1.3 m wide. It is equipped at each end with a swivelling door with an automatic closing system and a badge decoder. The floor of the chamber is covered with a contact mat which detects when a person passes or is present. In the middle of the chamber, there is a second contact mat independant of the first one and which can only hold one person. The requirement "only one person in the chamber at a time" is fulfilled when there is : "0" on the main contact mat
"1" on the small contact mat.

We can now describe the access procedure once the security conditions have been fulfilled. The person presents himself at the entrance of the chamber and is identified by introducing his badge into the decoder. The door opens and the person may enter the chamber. The door closes. The person walks onto the small contact mat. If the requirement "Only one person in the chamber at the time" is checked, the person may release the chamber's second door by pressing on the appropriate push-button. He may then enter the controlled zone.
The passage is then taken into account. The door automatically closes and is ready to allow another person to pass through.
All the security and access control for any room is processed on the spot by a microprocessor (8080A).
The central computer MITRA 125 is kept informed both of the positions of the various safety devices and all persons passing through. It also maintains a list of persons entitled to enter the controlled areas, prints a logbook giving all changes in state, each passage through the chamber and responses to an operator's questions etc. Furthermore it controls a colour screen which give to the SPR operator all informations pertinent to the state of the rooms, the beam security, the emergency halts, failures, etc...

The accelerators building will accomodate the complete radiation control and access control systems during the last quarter of 1981 and should be operationnal for the first tests in SSC1.

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