



Manual

The present document is interrelated with “Radiation protection at Elettra” GREL-MAN-01

The personnel safety system of Nanospectroscopy/NanoESCA beamlines

Process: GREL – Elettra - Radiation protection management

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3.1 Introduction

Exit: 1.2
Type: undulator
Beamlines: Nanospectroscopy and NanoESCA
Hutch: FE

Nanospectroscopy beamline utilizes the synchrotron radiation produced by the electrons passing through the undulator placed in the ring straight section n. 1.

The first part of the beamline is enclosed inside shielding walls and is called “Front-End hutch” (or “FE hutch”). The FE hutch is located just outside the ring shielding walls (see. Fig.3.1).

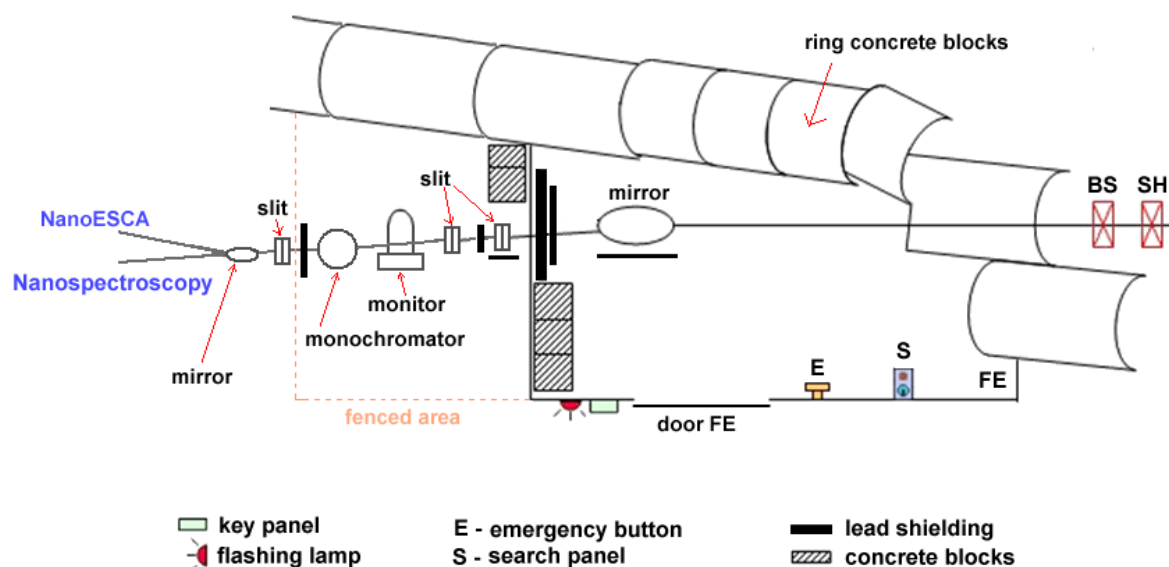


Figura 3.1. Rappresentazione schematica della hutch del front-end.

The front-end hutch houses a toroidal mirror. A system of horizontal and vertical slits placed out of the hutch is used to define the dimensions of the beam which is transported in vacuum up to the beamline monochromator. monochromator of the line which allows to select the energy of operation. The beamline uses the synchrotron light in an energy range between 25 and 1000 eV for photoelectron microscopy studies.

At the exit of the monochromator there is a further system of vertical slits and a flat mirror which is used to deflect the beam towards the experimental station of Nanospectroscopy line or towards the experimental station of the NanoESCA branch-line.

The penetrating gas bremsstrahlung gamma rays, produced inside the ring by the interaction of the electron beam with the residual gas of the vacuum chamber, is stopped by the lead and the concrete shielding placed both inside and outside the front-end hutch.

The vacuum chamber itself constitutes the shielding against the synchrotron radiation.

3.2 Logic of the safety system

The access control system is based on wired circuits programmed with a redundant logic and “fail-safe” philosophy (the Programmable Logic Controller or PLC).

The main safety elements on which the access control system PLC is based are:



- the BeamStopper (BS) for the gas bremsstrahlung, the SHutter (SH) for the synchrotron radiation placed in the beamline front-end, inside the shielding wall
- the gamma dose monitor located outside the hutch and aligned with the straight section of the ring.

The beamline safety system distinguishes two type of injection:

- *refill injection*, carried out with BS/SH closed and disabled to aperture, typically utilized to restore the beam inside the ring after a *dump* or an important decrease of current
- *top-up injection*, carried out with BS/SH eventually open, at short time intervals (e.g. every 5 minutes), in order to keep constant to the maximum value the current stored inside the ring.

Top-up injection is never disabled by the beamline safety system (but can be disabled by the machine safety system). On the contrary, refill injection can be interrupted or disabled, as described in the following paragraphs. From now on, in the next part of the chapter, when we speak of “injection”, we refer to refill injection.

3.2.1 Conditions for access to the FE hutch

Access inside the hutch is allowed if the following conditions are met:

- the injection of the electron beam inside the ring is not in progress;
- BS and SH must be closed;
- the gamma monitor indicates no failure, no pre-alarm and no alarm status;
- the PLC of the beamline is on.

3.2.2 Key panel

A panel with 2 locks and 4 lamps is located outside the hutch, close to the door.

If the safety conditions for entrance are fulfilled, the “B” key, taken by the beamline responsible (“R”) or by the authorized personnel, inserted into the first keyhole and turned, unlocks the “C” key which can be extracted and used to open the door.

The lamps show the “injection in progress”, the open/closed status of BS and indicate if BS is enabled to be opened.

The list of these lamps and their meanings are reported below:

- red lamp switched on: BS is open
- green lamp switched on: BS is closed
- white lamp switched on: BS and SH can be opened
- lower red lamp switched on: “injection in progress”.

A flashing red lamp on the hutch wall indicates the opening of both BS and SH.

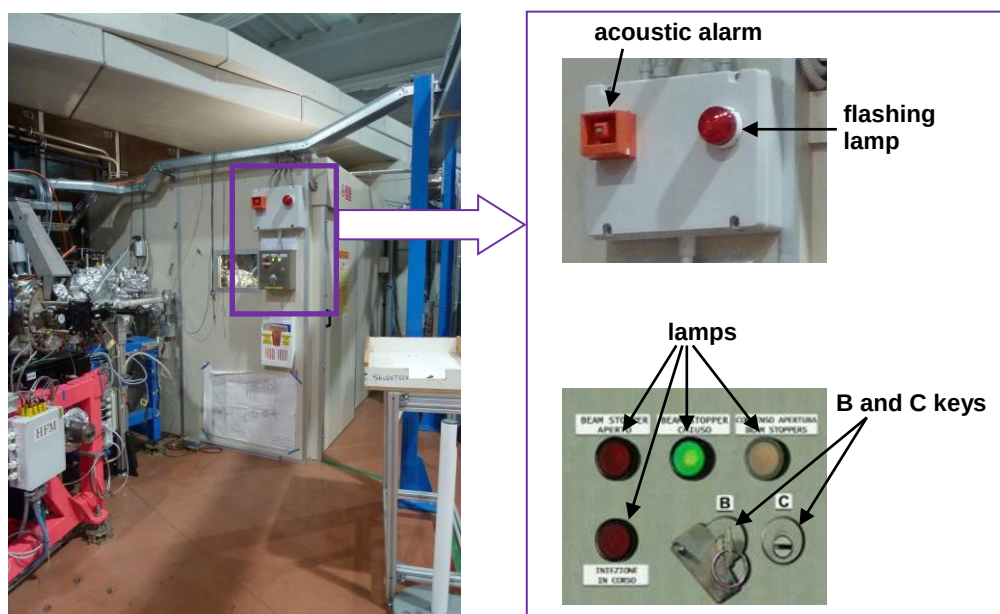


Figure 3.2. Acoustic alarm, flashing lamp and key panel of one of Elettra hutches.

3.2.3 Entrance operations

Entrance operations are reported below:

- R closes BS and SH
- R inserts the B key in the keyhole and turns it (*BS and SH are locked*)
- R takes the C key out (*this action locks the B key*)
- R opens the door using the C key.

3.2.4 Exit operations (“search” procedure)

At the end of operations an inspection (“search”) must be executed to verify that nobody is still inside the hutch before opening BS and SH. A search panel with a lock fitting the C key and a button is placed inside the hutch.

The search is performed as follows:

- R asks everybody to leave the hutch, enters and closes the door bringing the C key with him
- R verifies that nobody is still inside the hutch
- R inserts the C key in the search lock and pushes the search button turning the C key at the same time
- R leaves the hutch, bringing the C key with him, and closes the door
- R inserts the C key in the key panel outside the door within 30 seconds, turns it and extracts the B key within 10 seconds.

The first timer starts when the search button is pushed and is reset when the C key is turned in the panel outside the hutch. Further 10 seconds are allowed to extract the B key (the action is completed when the sensor is in the vertical position).

If the search is not correctly carried out, the safety system generates an anomaly status.

3.2.5 Conditions for opening BS and SH

BS and SH can be opened if the following conditions are met:



- the FE hutch door is closed and the search has been successfully carried out;
- the injection of the electron beam inside the ring is not in progress;
- the gamma monitor indicates no failure, no pre-alarm and no alarm status;
- the PLC of the beamline is on.

If, in an anomaly status, BS does not close within 10 seconds from a PLC request, a beam dump is forced inside the ring.

The BS and SH aperture may be inhibited also by other independent equipment.

3.2.6 Beam injection interlock

The beam injection in the ring is locked (or is interrupted) if:

- the door of the hutch is open (or is forced open);
- the hutch has not been searched;
- BS is open;
- the gamma monitor is off, indicates a failure or an alarm status;
- the PLC of the beamline is off.

3.2.7 Anomaly status

An anomaly status is generated if:

- the hutch emergency button is pushed
- the hutch door is forced open
- the search is not correctly carried out.

An anomaly status causes:

- the acoustic alarm switching on
- the injection inhibition or the injection interruption if the operation is running
- the BS closure (if open) and lock.

An anomaly status is reset carrying out a search. Before beginning the procedure, the anomaly causes must be reset.

3.2.8 PLC switching off

The PLC switching off causes:

- the injection inhibition or the injection interruption if the operation is running;
- the impossibility to enter the hutch;
- the beam dump in the ring;
- BS and SH closure (if open) and lock.

When the PLC is re-switched on an anomaly status is generated. The anomaly is reset by a successfully executed inspection (search).

3.2.9 Interlocks from the gamma monitor

The radiation monitor permits to measure locally around the beamline the gamma radiation dose rate and integrated dose.



Figura 3.3. Gamma radiation monitor.

The dose rate is measured second by second and then averaged on a minute and on an hour; results are shown locally on the monitor display and remotely on a computer placed in the ring control room, where data are continuously recorded.

The integrated dose is calculated, from the dose rate measurements, on time periods of 4 hours (from 0.00 to 4.00, from 4.00 to 8.00, from 8.00 to 12.00, from 12.00 to 16.00, from 16.00 to 20.00, from 20.00 to 24.00); after each period the measurement is reset and re-initialized.

The gamma dose monitor provides, as output, 3 logic signals:

- No-failure
- Pre-alarm
- Alarm.

The first signal (“No failure”) switches off in case of failure. The “Pre-alarm” switches on if a pre-alarm threshold fixed on the dose rate or on the integrated dose is exceeded. The “Alarm” switches on if an alarm threshold fixed on the dose rate is exceeded. The following table summarizes all the pre-alarm/alarm limits.

	Limit on the dose rate	Limit on the integrated dose
Pre-alarm	3 $\mu\text{Sv/h}$ for at least 360 s	2 μSv in 4 ore
Alarm	6 $\mu\text{Sv/h}$ for at least 180 s	

Tabella 3.1. Limits fixed on the dose rate and on the integrated dose.

The beamline safety system acquires these signals and generates different actions according to the logic described below.

“No failure” status OFF (= malfunction ON) causes:

- the impossibility to enter the hutch;
- BS and SH closure (if open) and lock;
- the injection inhibition or the injection interruption if the operation is running.

“Pre-alarm” status ON (= pre-alarm threshold exceeded) causes:

- the impossibility to enter the hutch;
- BS and SH closure (if open) and lock.

“Alarm” status ON (= alarm threshold exceeded) causes:

- the impossibility to enter the hutch;
- BS and SH closure (if open) and lock;
- the injection inhibition or the injection interruption if the operation is running.



It is important to note that, if the Pre-alarm is generated by the exceeding of the dose rate limit, it will switch off after the beamstopper closure, because the dose rate will decrease to less than 3 $\mu\text{Sv/h}$. On the contrary, if the Pre-alarm is generated by the exceeding of the integrated dose threshold, it will remain on also after the beamstopper closure until the end of the 4 hours. Throughout this period, access to the hutch will be interdicted and beamstopper aperture will be disabled.

3.3 Radiation emergency inside a hutch

A 'possible radiation accident' may occur if one or more persons remains inside a beamline hutch when the access is forbidden by the safety system.

In case that, after the search execution inside a hutch

- a person is suspected to be, or really has remained, inside the hutch
- an emergency button is pressed inside the hutch
- a hutch door is forced open

you must:

- immediately close the beamstopper (shopper)
- enter inside the hutch following the regular access procedure
- inspect the hutch
- if necessary, give assistance.

If the event takes place before the opening of the beamstopper (shopper), the assistance regards only ordinary safety.

If the alarm takes place after the opening of the beamstopper (shopper), an ionising radiation accident may have occurred.

IN THIS CASE YOU MUST IMMEDIATELY INFORM THE CONTROL ROOM OPERATOR OF WHAT HAS HAPPENED SO THAT HE CAN ACTIVATE THE PROVIDED PROCEDURES.

