# RADIATION AND LASER SAFETY SYSTEMS FOR THE FERMI FREE ELECTRON LASER*

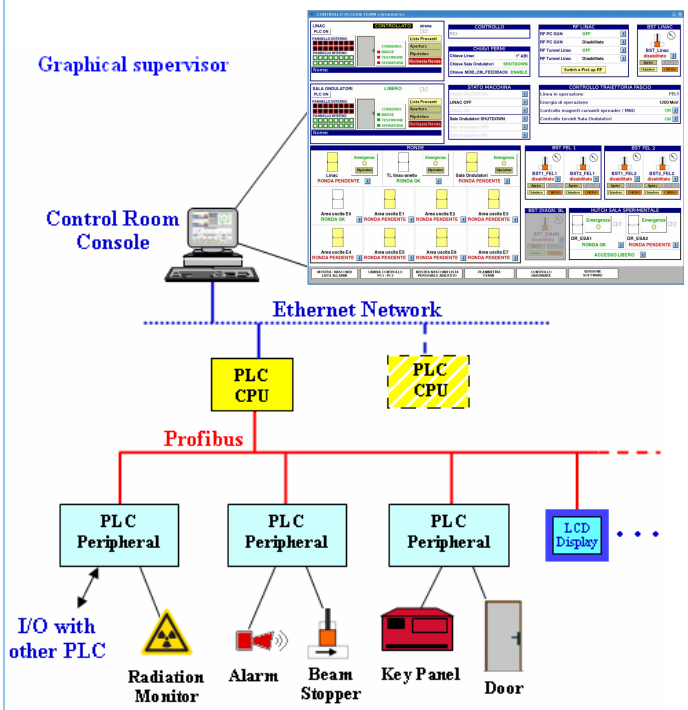
**MOPPC049**

**F. Giacuzzo, L. Battistello, K. Casarin, M. Lonza, G. Scalamera, A. Vascotto, L. Zambon,**
**Elettra Sincrotrone Trieste, Trieste, Italy;**
**G. Marega, Studio di Ingegneria Giorgio Marega, Trieste, Italy**

**FERMI is a Free Electron Laser (FEL) users facility based on a 1.5 GeV electron linac. The personnel safety systems allow entering the restricted areas of the facility only when safety conditions are fulfilled, and set the machine to a safe condition in case any dangerous situation is detected. Hazards are associated with accelerated electron beams and with an infrared laser used for pump-probe experiments. The safety systems are based on PLCs providing redundant logic in a fail-safe configuration. They make use of a distributed architecture based on fieldbus technology and communicate with the control system via Ethernet interfaces. The paper describes the architecture, the operation modalities and the procedures that have been implemented. The experience gained in the recent operation is also reported .**

**Introduction: In the FERMI Free Electron Laser, the electron bunches accelerated at energies up to 1.5 GeV, together with a tunable UV seed laser beam, are sent into a chain of undulators where they generate ultra short and high peak power coherent photon pulses with variable polarization in the soft X-ray spectral range. Two distinct undulator chains are available, FEL 1 and FEL 2, covering the entire spectral range from 4 to 100 nm. Two safety systems are in charge of protecting people by denying access to dangerous areas and implementing the necessary interlocks to switch off the beams in case of danger. The first is the system for the protection from radiation hazards, also referred as Personnel Safety System (PSS); the second, referred as Laser Safety System (LSS), protects people from the users laser used for pump and probe experiments.**

## SYSTEMS ARCHITECTURE AND TECHNOLOGIES



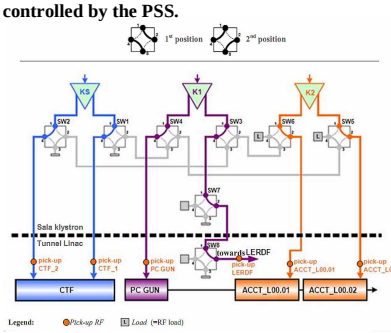

**Block diagram of the safety systems architecture.**

**The general design philosophy has been to use fail-safe devices whenever possible and, if not, redundancy and diversification of sensors and actuators have been adopted. Fail-safe versions of PLC (Siemens S7 315F, fieldbus (Profisafe) and I/O peripherals have been employed. One or more CPUs are in charge of the execution of the control programs, while a number of distributed I/O peripherals connected through the fieldbus, interface all of the controlled devices. The PSS includes two CPUs and 25 Profibus peripherals with 474 digital I/Os and 12 analog inputs, while the LSS features one CPU and 7 peripherals with 137 digital I/Os.**

**The connection of the PLCs to the FERMI control system is made via an Ethernet TCP/IP interface. Graphical supervisors running in the control room consoles have been developed to monitor the state of the safety systems and allow operators to manage access and search procedures. They communicate with the PLCs through dedicated Tango device servers, which are also in charge of logging into an archive database every event related to the systems. The supervisors are made of a main graphical synoptic and a number of specific panels. In order to guarantee quick resolution of anomalous situations the supervisors provide operators with comprehensive information on the state of the safety systems, including on-going accesses and search procedures, as well as with significant details of every controlled device and of the PLC internal state machine.**

## PERSONNEL SAFETY SYSTEM (PSS)

**From the radiation safety point of view the FERMI facility is divided in three main areas: the linac tunnel, the undulator hall and the safety hutch. The main radiation sources are the electron beam and the RF accelerating sections due to the high electromagnetic field generated inside them. The linac is made of several accelerating structures fed by 16 RF plants. The Cavity Test Facility (CTF), the photo cathode gun and the first two accelerating sections are connected to the first three plants (KS, K1 and K2) through a group of eight waveguide switches that can be set according to 12 possible configurations. The waveguide switches are controlled by the PSS.**

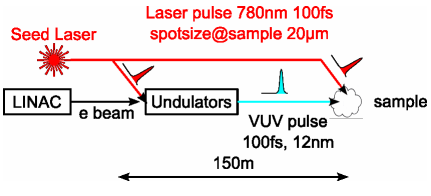



**Layout of the waveguide switch system of the first part of the linac.**

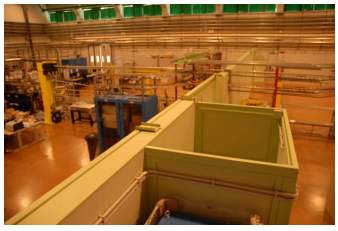
**Three machine operation modalities have been defined to access both the linac tunnel and the undulator hall: *Shutdown*, *Off* and *On*. A key panel placed in the control room and connected to the PSS allows defining the working modality. When the machine is in *Off*, the radiofrequency inside the tunnel is disabled as in the *Shutdown* modality, but the access is restricted and personnel can enter the two areas following the controlled access procedure. With the machine set in this operation modality, operators can also perform the tunnel search to assure that no people are inside.**

## LASER SAFETY SYSTEM (LSS)

**An infrared laser derived from the seed laser source is used for pump-probe experiments in the FERMI beamlines. The laser beam is transported through a 150-meter long vacuum pipe and some deflecting mirrors to the experimental area and then delivered to the selected experimental station using a switching deflecting mirror. This class-4 laser can produce serious damages to the eye retina, therefore the beam is fully shielded, the windows filtered and any removable part is interlocked to confine the beam and avoid any leakage in the experimental hall. An additional safety system with automatic interlock functionalities and the access control of the areas where the laser is used further improve the safety. A wall has been built to segregate the area around the experimental stations with controlled doors and access procedures. With this solution the experimental hall becomes a multi users area, people have to wear the safety eyeglasses for very short time.**




**Pomp probe experiments using the seed laser for users.**



**The experimental hall with the wall and the controlled doors.**

**The badge reader and baton panel next to the linac door.**

*Work supported in part by the Italian Ministry of University and Research under grantsFIRB-RBAP045JF2 and FIRB-RBAP06AWK3