SIEMENS

DSi
Deterministic Systems, Inc.

Easily scalable and maintainable radiation and laser personnel protection

Lawrence Berkeley National Laboratory (LBNL) in Berkeley, California is the location of the discovery of many atomic elements from plutonium in 1940 though seaborgium in 1974. In the very building where seaborgium was first created, a new femtowatt laser named BELLA has been installed. When it is fully operational, BELLA will be one of the most powerful lasers in the world, yet the entire system occupies only four moderate sized rooms.

The lasers and laser control systems were supplied by the French manufacturer Tales. Additional laser controls and equipment were constructed by LBNL themselves. But on top of these systems, a system is needed to protect the people who use the system from being harmed. The personnel protection system (PPS), charged with protecting all staff and visitors both from harmful radiation and laser light exposure, was designed and implemented by Deterministic Systems (DSi) of Walnut Creek, California. For the PPS, DSi chose to use the Siemens Industry Safety PLC platform.

Proven History with Siemens Safety

Previously, DSi has successfully implemented a Siemens S7-319F based radiation personnel protection system in another room of the building, known as Cave A. It prevented access to the room when harmful radiation could be generated. Also, it disabled the source of radiation when the room had not been checked for the absence of people or some failure of the system allowed it to be accessed. This single room system consisting two IO panels and one touchscreen HMI was the first non-relay based safety system at LBNL. It controlled access via one door and also controlled and monitored 2 radiation detectors, 2 search & clear panels, and redundant laser system enable communication relays.

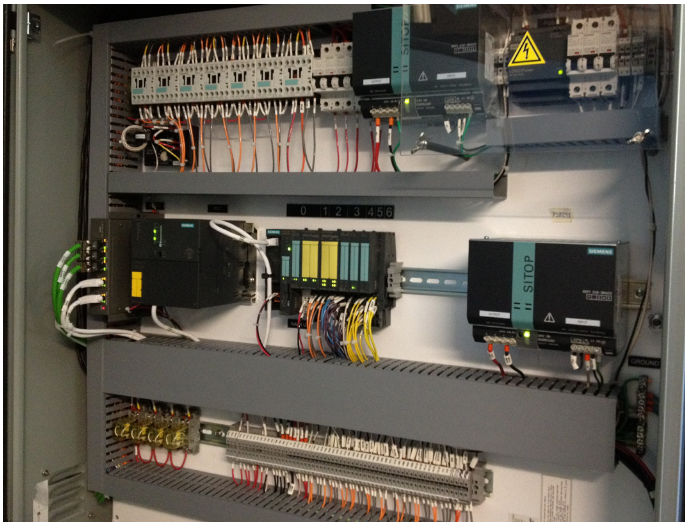
Existing relay based systems on the lab are difficult to modify or expand. They also offer little to no diagnostic capabilities. Although redundant, they cannot detect a short circuit to a sensor coming from another system. Siemens safety PLCs use redundant failsafe inputs which can detect short circuits to each other and to other sources of power. They also use failsafe outputs which can also detect short circuits to themselves whether they are on or off.

A safety PLC system was chosen for Cave A because LBNL needed the flexibility that a safety PLC based system would allow them to achieve. They chose to go Siemens because of Siemens's long history with safety control systems based on standard Ethernet communications, and chose DSi as their system design and integrator because of DSi's experience with the Siemens Safety PLC platform.

Control System

For BELLA, LBNL wanted to go with the same proven Siemens Safety PLC used in Cave A, distributed IO, and HMI architecture using PROFIsafe over Profinet. By using the same system installed in Cave A, LBNL benefits by not having to train personnel on two different systems. Also, the same replacement parts can be used on both systems.

They chose to work DSi again because of the trouble-free experience they had with Cave A. "The ability to send safety information and control from one room to another using only Ethernet and a set of power wires made the design clean and easily modifiable during the design phase," says David Di Giorgio, DSi's lead engineer on the Cave A and BELLA projects. "In the future, this will also allow LBNL to modify the system to continue to fulfill their needs as the needs of the experiments change."



The control and monitoring are achieved with a single Siemens S7-319F safety PLC and four remote safety IO racks located in panels residing in the four rooms that comprise BELLA.

Four Siemens touchscreen HMIs are located in the rooms to allow staff to control and monitor the system. One HMI is used for radiation control, functions similarly to the one HMI used for Cave A's radiation control. The remaining three HMIs are located in the three rooms that comprise BELLA's 3 laser safety zones. Each HMI allows a user to monitor the entire system but, for safety's sake, only allows the user to control devices located in the laser safety zone the HMI is located in. Indicators on the HMI show the status of all the safety devices in the system. They show not only if the device is on or off, but if it has failed electrically. Separate local and global active alarm lists of both custom safety alarms and automatically generated alarms indicate where the problem is in the system. Global and local alarm logs allow users to not only view the history of alarms but allow notes about major mode changes in the system to be recorded for evaluation.

Although all 4 HMIs function differently, many features are the same on all of them. All four were all coded with a single program that simply requires a different integer to be set before downloading the program to identify which HMI it is and have all the buttons respond accordingly.

The design of the Cave A system was greatly expanded to accommodate the great increase in the number of devices and the wider variety of devices controlled for BELLA. BELLA has 14 access doors used to keep people out of areas that they can't safety enter. 13 of these doors are used for laser safety. Based on the access privileges of a user trying to enter a door, the system allows door with mag locks to be unlocked as long as other doors in the system are closed, producing a man trap which prevents laser light from exiting any BELLA Laser Zones enabled for laser light production. Other doors without mag locks are only monitored. If they are detected open when the Laser Zone they allow access to is enabled, the PPS will safety shut the laser system down. Shutting the lasers down is achieved through control of 18 laser shutters, three laser beam dumps, and 17 laser power supply enable circuits. Two large window shutters also block two large picture windows which allow viewing the main laser bay while the laser is not active. If the system detects that either of these is not closed, it safety shuts the lasers down.

One access door leads to the Experimental Cave which is the only zone where radiations should be produced. Along with the use of three search & clear panels, the PPS properly walks personnel though BELLAs Experimental Cave to investigate the room before the system will allow a combination of devices to be enabled that could potentially create radiation in that area. Once the PPS insures that the area has been fully checked, the door to the Experimental Cave is locked and multiple flashing lights and buzzers warn people inside and outside the cave that the system will soon be enabled for High Energy Mode. After a period of time, High Energy mode is enabled.

Whether High Energy mode is enabled or not, 2 radiation monitors located outside of the Experimental Cave will shut down the main laser shutter if radiation above a certain level is detected outside the cave.

The Future

From the beginning, the system already has two different configurations that are planned to run on the system. While the laser is being setup, a special Commissioning Mode will allow people into the Experimental Cave while High Energy can be produced, but during this time, not devices will exist that could potentially cause radiation. Once those devices are installed and people are no longer allowed into the Experimental Cave, a new program will be put into the system which completely removes this mode.

Before the system will be ready for use again, the new program will be re-validated and the safety compilation time and checksum visible on all the HMI's showing which program is loaded. Once this has been done, LBNL can load the program they need to use for the particular phase the laser is in allowing them to quickly change the system without changing a single wire.

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