

RADIATION SAFETY INTERLOCK SYSTEM FOR DCLS

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Abstract

Dalian Coherent Light Source (DCLS) is in the design phase currently and will be constructed in Dalian from 2013. It is a seeded HGHG-FEL, mainly consisting of one 300 MeV electron linear accelerator and one undulator. Radiation safety is one of the most important tasks for Dalian FEL. Radiation safety interlock system (RSIS) is designed to prevent personnel exposure to high radiation levels, based on the As Low As Reasonably Achievable (ALARA) principle. RSIS controls access to the radiation protection areas and monitors safety devices. Only if all the radiation safety conditions are satisfied, then the facility will be permitted to operate. Once any condition is broken, RSIS will send a signal to stop the electron beam immediately to guarantee radiation safety. The core component of RSIS utilizes Programmable Logic Controller (PLC), which is a proven and reliable technology in the field of industrial automatic control. All safety-relevant functions of RSIS are implemented with fail-safe components. The hard wiring cable of the peripheral signals for the safety-relevant functions is redundant. The safety interlock signals are sent via a fail-proof protocol and transferred redundantly.

INTRODUCTION

Dalian Coherent Light Source (DCLS) is an experimental apparatus for basic energy sciences using tunable VUV. DCLS is in the design phase currently. It will be constructed in Dalian from 2013 and should be ready for operation in 2015. DCLS is a seeded HGHG-FEL, mainly consisting of one 300MeV linear accelerator and one undulator. The bunch parameters of electron gun are charge 0.5nC, repetition rate 50Hz and pulse width 10ps. The layout of DCLS is shown in Fig. 1. The electron beam energy is 5MeV after RF-Gun, 130MeV after Injector and 300MeV after LINAC. Radiation losses in the whole facility will generate ionizing radiation in the form of gamma and neutron radiation. Radiation safety interlock system (RSIS) is designed to prevent personnel exposure to high radiation levels.

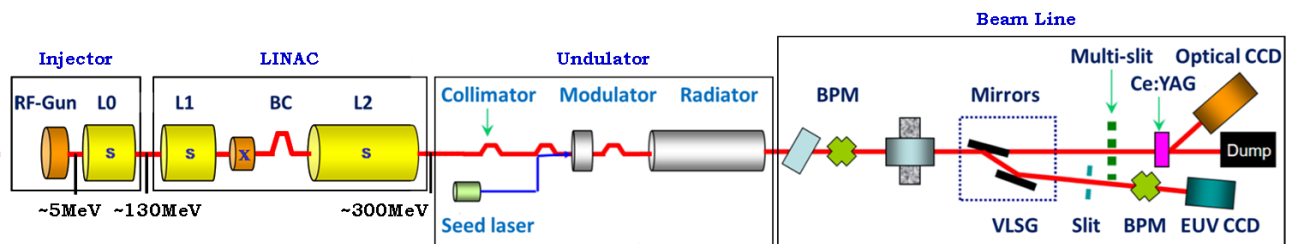


Figure 1: Layout of DCLS.

RADIATION SAFETY INTERLOCK SYSTEM

RSIS controls access to the radiation protection areas and monitors safety devices. Only if all the radiation safety conditions are satisfied, then the facility will be permitted to operate. Once any condition is broken, RSIS will send a signal to stop the electron beam immediately to guarantee radiation safety. RSIS consists of four modules as shown in Fig. 2. *Interlock Control Module* collects interlock signals generated from other three modules, and control the permission signals for RF-GUN and other RF systems.

Access Control

There are three access modes in RSIS for DCLS accelerator tunnel as shown in Table 1. These modes can be transferred in different scenarios and conditions as shown in Fig. 3. Status Indicators (audio & visual) and LED Displays (text) are utilized for indicating the state of accelerator tunnel.

Table 1: Access Modes

Access Mode	Tunnel	Electrical Hazards	Beam	Access
Controlled Access	Not been Searched	Off	Off	Lower Permission ID card
Restricted Access	Searched and Secure	May be Energized	Off	Higher Permission ID card & Key
No Access	Interlocked	May be On	May be On	No Permission

Search Procedure must be performed for the transfer from *Controlled Access Mode* to *Restricted Access Mode*. Its function is to ensure that no person remains in the interlocked tunnel before the machine running. It is controlled by search buttons with a specific sequence and

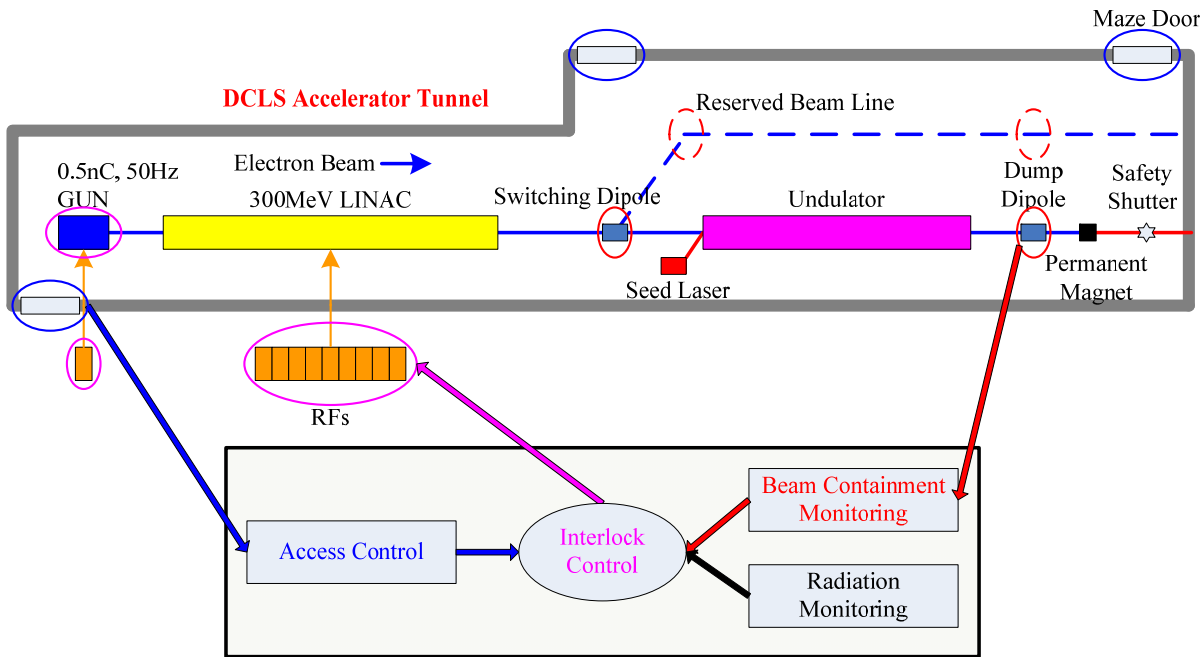


Figure 2: Radiation Safety Interlock System.

time window between two search buttons. The search procedure must be cancelled and repeated if a wrong sequence is triggered or time window is exceeded. Search button with status lamp can be applied. Only the status lamp of the next button to be pressed will be set to flash. In this way, the inadvertent omission of search buttons will be prevented.

There is a kind of ID Card with higher permission to start search procedure.

Emergency Stop Monitoring System monitors the state of emergency stop buttons. When an Emergency Stop is triggered, the state should be kept until the button is released locally. Beam must be terminated within 20ms when any emergency stop is monitored since the repetition rate of GUN is 50Hz.

Beam Containment Monitoring

One switching dipole is designed to switch electron beam between two beam lines. One kick-back dipole bends electron beam back to the reserved beam line. Dump dipole bends electron beam into dump. Dump dipole is followed by a permanent magnet for fail-safe in the case that dump dipole doesn't work. Hence, the 4 electromagnets mentioned above need to be monitored by beam containment monitoring system to ensure electron beam is discarded into beam dump eventually.

Radiation Monitoring

Two types of detectors (gamma and neutron) are contained in area radiation monitoring system. Ionization chamber filled with high pressure argon is adopted as gamma detector. BF3 proportional counter surrounded by polyethylene moderator is adopted as neutron detector. One gamma detector and one neutron detector are mounted in pairs at each monitoring location. Local audible siren and visual display are used to warn personnel near the area when an unexpected high radiation level occurs. Monitors at some critical locations can be interlocked to RSIS when the preset limit radiation level is surpassed.

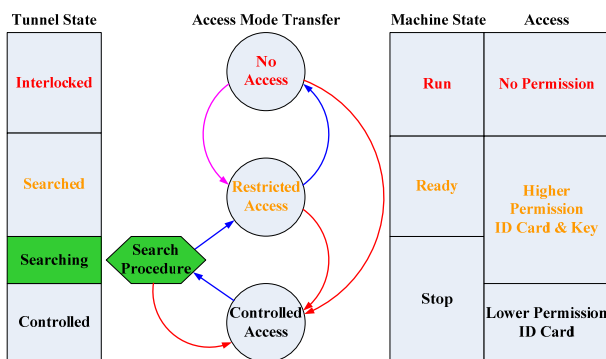


Figure 3: Access Mode Transfer.

ID Card System is used to distribute access permission to personnel. Each personnel can get an access ID Card with the accessible scope of time and areas properly defined. All the access information will be automatically recorded by a control computer. In Restricted Access Mode, the access into accelerator tunnel must be authorized by the console at the centre control room.

Beam Line Interlock

There is a safety shutter in the end of the front-end area of each beam line. Personnel will frequently go into optics hutch from experimental area. Hence the door of the optics hutch and the safety shutter should be interlocked. Search procedure is also needed before the safety shutter is opened. Status Indicators (audio & visual) and LED Displays (text) are also needed for optics hutch as well as for tunnel area.

PLC-BASED HARDWARE ARCHITECTURE

The core component of RSIS utilizes Programmable Logic Controller (PLC) as shown in Fig. 4, which is a proven and reliable technology in the field of industrial automatic control. All safety-relevant functions of RSIS are implemented with fail-safe components. The hard wiring cable of the peripheral signals for the safety-relevant functions is redundant. The safety interlock signals are sent via a fail-proof protocol and transferred redundantly.

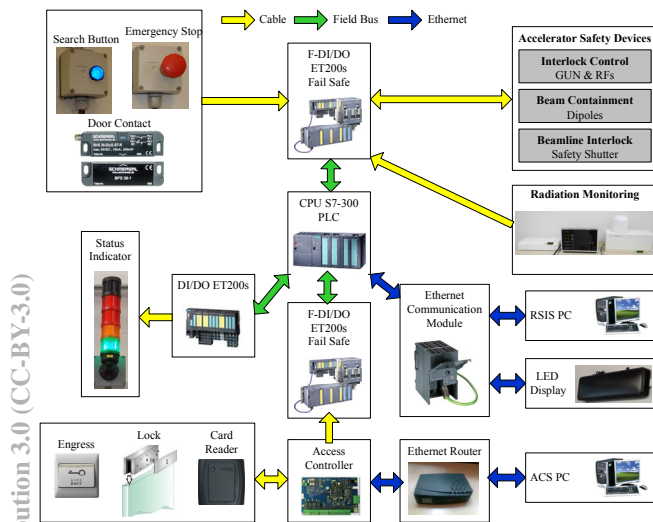


Figure 4: PLC-based Hardware Architecture.

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