

BROOKHAVEN NATIONAL LABORATORY		Number: PO-P-ATF-0025	Revision: 1
PHYSICS DEPARTMENT		Effective: 08/12/2004	Page 1 of 9
Subject: ATF Laser Interlock System		Prepared by: Marcus Babzien	
Reviewed by ES&H Coordinator: 	Approved by ATF Head: 	Approved by Department Chair: 	

ATF LASER INTERLOCK SYSTEM

I. Introduction

A PLC (Programmable Logic Controller) based system with a distributed I/O communicates with the various laser rooms through a twisted pair data buss (Modbus Plus) connected to I/O modules in the individual rooms. Figure 1 is a layout of the accelerator Test Facility showing the various rooms containing the lasers.

The classification of the hazard according to BNL ES&H standard 1.5.3 is "critical". This classification requires the system to be fail safe, have an enforced search, require operator restart and be periodically tested. The PLC and the interlock system are designed to default to a safe state in the event of open circuits, disconnected data buss, or loss of power. The rooms are equipped with a series of check stations that must be pressed in a sequence to enforce a search of the area before it is secured. If the security of the system is broken by a door or an emergency stop being pressed, it requires a new search and a device to be reset by an operator to enable operation or a laser source.

The rooms have the ability to be secured individually and have the provision to allow qualified personnel to enter the room while maintaining security. Shutter control is through a single key system where only one key exists for each shutter control. This allows a simple solution for control of the shutter by only one person at any time.

There are seven rooms where laser radiation is generated or can be sent to, they are: Experimental Hall (EH), CO₂ Room (CO₂), FEL Room (FEL), YAG Room (YAG), Gun Hutch (GH), Laser Lab (LL). Inside these rooms there exist dangerous levels of laser radiation posing both an eye and skin hazard. Refer to Figure 1 or controlled drawing ATF-488.1-3 for the location of lasers and shutters. Access to the rooms is controlled and only trained and authorized individuals are allowed to be inside the areas when laser radiation could be present. Laser tuning and optical alignment require access to the controlled areas by authorized individuals when the lasers are on.

For efficiency of operation it should be possible to enter and exit the laser room while the laser beam is on. In the case of the Experimental Hall there also exists a radiation hazard that is protected by a separate radiation interlock. In the Experimental Hall there will be no access during the time when the radiation interlock is secure. The laser interlock is separate in operation and circuitry from the radiation interlock.

Number: PO-P-ATF-0025	Revision: 1	Effective: 08/12/2004	Page 2 of 9
------------------------------	--------------------	------------------------------	--------------------

II. General Search and Secure Procedure

Each room has identical function in relation to the securing of the room. A start search button located inside of the room must be pressed and a physical search of that room must be carried out. After starting the search a blue flashing strobe will illuminate to visually warn personnel inside of the room that the area is being prepared for the introduction of laser radiation. The person conducting the search will then exit the room being searched along with other personnel found inside and press the complete search button located outside the room. You have 60 seconds to complete each search. An audible warning will then sound for 15 sec. to alert anyone inadvertently left inside the room that laser radiation could be imminent. After the warning sound is over the area interlocked sign will illuminate and the interlocking process is complete.

III. Authorized Access to Laser Rooms

Authorized access to rooms with operating lasers is accomplished without allowing laser radiation outside the room by using a "light lock." In the case of the LL, YAG and GH there is a vestibule outside the room entrance and only one door may be open at a time. Buttons are provided at each door to request passage and indicators show system permission to open a door. A door may be open for a maximum of 20 seconds. If any of these conditions are violated, the interlock for that room is dumped and the area must be re-searched. When the area security is violated an audible warning will sound for 5 seconds both locally and in the control room. To turn off the interlock in an orderly fashion in order to enter the Secured areas without enabling the alarms there is an Interlock Off button located on the interlock box inside the area and a button located on the outside marked "INTERLOCK OFF."

IV. Emergency Off

Located in each room there is an emergency stop button to turn off the source of laser radiation that supplies that room in the event of a person being inadvertently left in the secured area or in an emergency situation. Pressing the emergency stop will require that the control room operator or person assigned responsibility for laser safety, reset the emergency stop latch circuit with the proper reset key. The reset switch is located on the interlock control box in each room. Located in the control room there is an emergency stop that will shut off all lasers in the facility if pressed.

V. The Vestibule

The entrances to the YAG room, Gun Hutch and the Laser Lab are connected by a small room called the vestibule. The vestibule serves as a light lock for all three rooms and allows entry by authorized individuals while laser radiation is present in the rooms. To enter the vestibule there is a passage button located by the door. To enter the individual presses a button until the LED on the box illuminates, opens the door, enters, then closes the door and presses the passage button inside the vestibule. The button has a LED illuminated on the box. Once inside the vestibule the individual will have the choice of entering three rooms: YAG, GH and LL. Only one door is permitted to be open at any time.

Number: PO-P-ATF-0025	Revision: 1	Effective: 08/12/2004	Page 3 of 9
------------------------------	--------------------	------------------------------	--------------------

Located outside the vestibule door are status indicators, these indicators show the status of the wavelength of light present or the potential wavelength present in the vestibule room. This is to aide the individual in making decisions before entering the vestibule door.

VI. Gun Hutch (GH)

Hazards in the GH room are generated in the YAG laser located in the YAG room.

The GH room has the standard search logic. The door bypass for the entrance is located outside the YAG room in the vestibule. Entry is granted to the GH room by pressing the passage button and waiting for the LED to illuminate, opening the door and entering, then closing the door and pressing the passage button with the LED illuminated. To exit the room the procedure is reversed.

Operation of the shutter that directs laser energy into the GH room can be controlled from two locations, the control room and the control box located in the GH. The control consists of a keyswitch for each shutter with only one key for each shutter. On the control box there are LED's that indicate the open and closed positions of the shutters. Each shutter has an enable light to indicate if it is possible to open the shutter.

Located in the GH is an emergency stop button, blue in color. This button, if pressed, will remove the permit to the manufacturer supplied interlock for the YAG laser. Once the emergency stop is pressed it requires that the control room operator goes to the GH and reset the ES Latch with the reset key.

Located inside the vestibule is a status indicator. This indicator shows the status of the wavelength of light present or the potential wavelength present in the GH room. This is to aide the individual in making decisions before entering the GH room.

VII. Laser Lab Room (LL)

Hazards in the LL room are generated from a proposed laser of unknown type at this time, however, the provision for a laser and four shutters has been made.

The LL room has the standard search logic. The door passage button for the entrance is located in the vestibule. Entry is granted by pressing the passage button and waiting for the LED to illuminate, opening the door and entering, then closing the door and pressing the passage button with the LED illuminated. To exit the room the procedure is reversed. The YAG may be accessed through the east door. To maintain security in the LL room the east door may only be accessed while the YAG is secured.

Operation of all shutters that direct laser energy into the LL room can be controlled from two locations, the control room and the control box located in the LL. The control consists of a keywitch for each shutter with only one key for each shutter. On the control box there are LED's

Number: PO-P-ATF-0025	Revision: 1	Effective: 08/12/2004	Page 4 of 9
------------------------------	--------------------	------------------------------	--------------------

that indicate the open and closed positions of the shutters. Each shutter has an enable light to indicate if it is possible to open the shutter.

Located in the LL is an emergency stop button, blue in color, this button if pressed will remove the permit to the manufacturer supplied interlock for the future planned laser. Once the emergency stop is pressed it will require that the control room operator go to the LL and reset the ES Latch with the reset key.

Located inside the LL room by the east door and inside vestibule are status indicators, these indicators show the status of the wavelength of light present or the potential wavelength present in the LL room. This is to aid the individual in making decisions before entering the YAG room.

VIII. YAG Room (YAG)

Hazards in the YAG room are generated in the YAG laser located in the room and from a laser located in the LL that is planned for future use.

The YAG room has the standard search logic. The door bypass for the entrance is located the outside the YAG room in the vestibule. Entry is granted to by pressing the passage button and waiting for the LED to illuminate, opening the door and entering, then closing the door and pressing the passage button with the LED illuminated. To exit the room the procedure is reversed.

Operation of all shutters that direct laser energy into the YAG room can be controlled from two locations, the control room and the control box located in the YAG room. The control consists of a keyswitch for each shutter with only one key for each. On the control box there are LED's that indicate the open and closed positions of the shutters. Each shutter has an enable light to indicate if it is possible to open the shutter.

Located in the YAG room is an emergency stop button, blue in color, this button if pressed will remove the permit to the manufacturer supplied interlock for the YAG & Future laser. Once the emergency stop is pressed it will require that the control room operator go the YAG room and reset the ES Latch with the reset key.

Located outside the YAG room by the north door are status indicators, these indicators show the status of the wavelength of light present or the potential wavelength present in the YAG room. This is to aide the individual in making decisions before entering the YAG room.

Number: PO-P-ATF-0025	Revision: 1	Effective: 08/12/2004	Page 5 of 9
------------------------------	--------------------	------------------------------	--------------------

IX. CO₂ Room (CO₂Main)

The hazards present in the CO₂ Main room are from the CO₂ laser located in the room and from 1 μ m light generated in the YAG room.

The CO₂ Main room has the standard search logic. There is a light lock formed by two doors before entering the CO₂ Main room, the door leading to the outside of the building (the east door) and the CO₂ Main door. The passage procedure is the same as in the EH. Entry is granted to authorized individuals by pressing the passage button and waiting for the LED to illuminate, opening the door and entering, then closing the door and pressing the passage button with LED illuminated. This process is repeated to enter the second door. To exit the room the procedure is reversed. The east door has a keypad instead of a pushbutton for the passage. The CO₂ Main room is divided into two areas that can be interlocked separately. In order to access the CO₂ AMP section of the CO₂ area, the shutters controlling the laser radiation going into the CO₂ Main room will have to be closed before passage is granted. Activating the passage interlock will close the appropriate shutters pertaining to this door. The reason for this is that there is no light lock separating the two sections of the room. Once in the CO₂ Main room the FEL may be accessed through the FEL south door. There is a light lock formed by two doors before entering the FEL room. The passage procedure is the same as in the CO₂ Main.

Operation of all shutters that direct laser energy into the CO₂ Main room can be controlled from two locations, the control room and the control box located in the CO₂ Main room. The control consists of a keyswitch for each shutter with only one key for each shutter. On the control box there are LED's that indicate the open and closed positions of the shutters. Each shutter has an enable light to indicate when it is possible to open the shutter.

Located in the CO₂ is an emergency stop button, blue in color, this button if pressed will remove the permit to the manufacturer supplied interlock for the L1 & L3 laser. Once the emergency stop is pressed it will require that the control room operator go the CO₂ room and reset the ES Latch with the reset key.

Located outside the east CO₂ Main door, CO₂ Amp Room and inside the CO₂ main room by the north door are status indicators, these indicators show the status of the wavelength of light present or the potential wavelength present in the CO₂ and in the FEL, respectively. This is to aid the individual in making decisions before entering the CO₂ or the FEL room.

X. Procedure for Securing the CO₂ Main and Amp Rooms Together During Pre-amplifier Testing

The wall between the CO₂ main room and the CO₂ amplifier room, labeled C2 and C1, respectively, has been partially removed to allow for equipment access to components of the preamplifier. Both rooms currently have separate control panels for the laser interlock system, and function independently. However, there is no longer a need to operate these rooms independently, and the amplifier room will merge with the main room at some point in the future. Until such time as the interlock system is updated, the penetration in the wall shall be

Number: PO-P-ATF-0025	Revision: 1	Effective: 08/12/2004	Page 6 of 9
------------------------------	--------------------	------------------------------	--------------------

minimized, and the two rooms always secured together. The administrative procedure for accomplishing this is detailed below.

Precautions:

1. If there is to be any operation involving delivery of class IV beam to either room, both must be searched and secured before delivering beam. Practically, this means that the amplifier room may no longer be unsecured when operating the CO₂ laser system or using the YAG slicing beam. The protection afforded by securing the CO₂ amplifier room is that it warns entering personnel that beam could be present, and makes the operator aware that unauthorized personnel have entered the room via the audible alarm. Although the shutters for the source lasers will not close if interlock is broken in the amplifier room, the operator will be responsible for immediately closing them and securing the amplifier room before resuming operation. Thus, the risk of unintended exposure is minimized.
2. The penetration between the two rooms shall be curtained off to the fullest extent possible to minimize the slight chance of a beam traveling through the penetration and accidentally entering the amplifier room.
3. The hazard classification for beam from the CO₂ laser oscillator, YAG 1 micron, and YAG 0.5 micron is class IV. Protective eyewear conforming to BNL safety requirements will be worn in both rooms at all times that beam is present. Eyewear must be labeled for optical density at all three wavelengths to meet these requirements.
4. All personnel involved shall be trained, authorized users of the ATF CO₂ laser. Only those personnel who have read and understood this procedure shall be permitted to use the laser beam in the CO₂ amplifier room.

XI. FEL Room (FEL)

The hazards in the FEL room come from the 0.25 -5 μ m laser light generated in the EH and transmitted through shutters BL1 to FEL, BL2 to FEL, BL3 to FEL. In addition are 0.5 μ m and 1 μ m laser light from the YAG room transmitted through YAG Laser, YAG to FEL and YAG to CO₂ main shutters.

The FEL room has the standard search logic. The door interlock passage button for the south entrance is located in the CO₂ Main Laser Room. There is a light lock formed by two doors before entering the FEL room. The passage procedure is the same as in the EH. Entry is granted to authorized individuals by pressing the passage button and waiting for the LED to illuminate, opening the door and entering, then closing the door and pressing the passage button inside with the LED illuminated. This process is repeated to enter the second door. To exit the room the procedure is reversed. Entry and exit can also be made to the FEL room or the CO₂ room through the east door located between the doors separating the FEL and the CO₂ rooms and leading outside the building. The east door leading to the outside building has a keypad for

Number: PO-P-ATF-0025	Revision: 1	Effective: 08/12/2004	Page 7 of 9
------------------------------	--------------------	------------------------------	--------------------

passage. The passage procedure is the same as above. The northwest door in the FEL that leads to the EH may also be passed to allow entrance into the EH room as described.

Operation of all shutters that direct laser energy into the FEL can be controlled from two locations, the control room and the control box located in the FEL. The control consists of a keyswitch for each shutter with only one key for each shutter. On the control box there are LED's that indicate the open and closed positions of the shutters. Each shutter has an enable light to indicate when it is possible to open the shutter.

Located in the FEL is an emergency stop button, blue in color, this button if pressed will remove the permit to the electron source through the reachback feature and removes the permit to the manufacturer supplied interlock for the YAG laser. Once the emergency stop is pressed it requires that the control room operator go to the FEL and reset the ES Latch with the reset key.

Located by the south FEL door and northwest door are status indicators, these indicators show the status of the wavelength of light present or the potential wavelength present in the CO₂ and in the EH respectively. This is to aide the individual in making decisions before entering the CO₂ or the EH room.

XII. Experimental Hall (EH)

Located in the EH are the electron beamlines and wigglers that produce laser radiation up to shutters BL1 to FEL, BL2 to FEL, BL3 to FEL. The CO₂ Oscillator light is piped into the EH from the CO₂ room and 0.5 μ m light from the YAG room is also piped into the EH. The Experimental Hall has the standard search logic but with the addition of two more check stations. These extra check stations are to enforce a complete search of the area due to the large physical size of the area. The EH is also different in that there is a labyrinth at the south entrance that will serve as a light lock, therefore only one door is needed at this location to maintain laser security and allow passage.

To enter the room after the area has been secured the passage button located outside of the EH south door is pressed until the LED illuminates, the door is opened and the room entered, once inside and the door closed, the passage button on the inside is pressed. The procedure is reversed to exit the EH.

The door between the EH and the FEL has no light lock, so passage between the rooms is permitted only if all shutters controlling laser radiation are closed. When the appropriate shutters are closed the passage buttons at this door may be used as described above.

Operation of all shutters that direct laser energy into the EH can be controlled from two locations, the control room and the control box located in the EH. The control consists of a keyswitch for each shutter with only one key for each shutter. On the control box there are LED's that indicate the open and closed positions of the shutters. Each shutter has an enable light to indicate when it is possible to open the shutter.

Number: PO-P-ATF-0025	Revision: 1	Effective: 08/12/2004	Page 8 of 9
------------------------------	--------------------	------------------------------	--------------------

Located in the EH are five emergency stop buttons, red in color, if either button is pressed it will remove the permit to the electron source through the reachback feature and will remove the permit to the manufacturer supplied interlock for the YAG laser and the CO₂ Oscillator. Once the emergency stop is pressed it will require that the control room operator go to the EH and reset the ES Latch with the reset key.

Located outside the south EH door and inside the EH by the northeast door are status indicators. These indicators show the status of the wavelength of light present or the potential wavelength present in the EH and in the FEL, respectively. This is to aid the individual in making decisions before entering the EH or the FEL room.

If security is dumped in any interlocked laser room due to a door being opened or any other reason, then the shutters which control laser radiation in that room will be commanded to close. If these shutters do not indicate closed in an appropriate time (0.5 second) then the interlock will "reachback" and turn off the radiation source: the laser power interlocks and/or the electron beam in the case of FEL radiation.

XIII. Control Room (CR)

Located in the control room are shutter control keys one for each shutter. There are indicator LED's to show the open and closed status of each shutter and an enable indicator. There is an emergency stop button that will shut off all lasers in the facility if pressed. When a laser room is entered without the proper sequence and the interlock is dumped, a 5 second warning will sound in the control room. The secured status and the emergency stop status for each room is displayed in the control room. There is an indicator that lights if there is a fault in the distributed I/O modules. The closed indicator for each shutter will flash in the event of the shutter command not being the same as the shutter position.

