

**LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY**

**– LIGO –**

CALIFORNIA INSTITUTE OF TECHNOLOGY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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<b>Safety Information for the Caltech 40 Meter Laboratory</b>		
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# 1 Purpose and Scope

This document will describe safety procedures and practices meant to protect the lives of personnel and visitors when working and/or visiting the LIGO 40meter lab. All safety precautions and procedures developed by The California Institute of Technology must be followed. City, County and State safety codes must also be followed when applicable .

All people working at the Caltech LIGO 40 Meter Interferometer Laboratory (including students and visitors) must be familiar with the safety and emergency response procedures put in place by Caltech, LIGO, and the 40 Meter Lab management. Familiarity and understanding of everything in this document is mandatory for all personnel working at the 40 Meter Lab.

There are regular safety briefings for all 40 Meter Lab personnel in which the material in this document is reviewed.

It is the responsibility of all personnel working in the lab to be aware of all safety issues relevant to themselves and *all other people present in the lab*, and keep safety considerations at the highest priority at all times.

## 2 Basic Caltech-wide safety and emergency response procedures

All people working at the Caltech LIGO 40 Meter Interferometer Laboratory should review and understand the Caltech emergency response procedures outlined in the Caltech emergency response guide, <http://www.safety.caltech.edu/crisis/erg.html> , which is posted at various places around the lab and the campus (orange and white signs). Caltech holds periodic safety training sessions. Summer students, in particular, are required to attend one of these sessions.

All laboratory visitors, including repairmen, firemen, etc, must be escorted at all times by a fully responsible laboratory member, unless fire or emergency personnel deem that to be unsafe.

All workspaces at Caltech must be safe and ergonomically sound. For more information on office ergonomics, see <http://www.safety.caltech.edu/ergonomics/index.html> .

## 3 Laser safety training

All personnel working at the 40 Meter lab for any length of time, and all personnel working with or in the vicinity of the 40 Meter Lab laser, must attend a mandatory Caltech laser safety lecture, watch a basic laser safety video, and read and understand the Caltech Laser Safety Manual, which can be found online at <http://www.safety.caltech.edu/publications/laser.html> .

The LIGO Lab specific Laser Safety Program is described in M960001-B-P, <http://docuserv.ligo.caltech.edu/docs/internal/M/M960001-B.pdf> . All 40 Meter personnel should read and understand this document.

The 40 Meter Lab has a lab-specific laser safety Standard Operating Procedure, described below. All personnel working at the 40 Meter lab for any length of time must also attend a lab-specific safety briefing, covering all the material in this document.

All personnel working with the 40 Meter lab lasers must comply with all instructions from the 40 Meter Lab Registered Laser Operators. All personnel working with the 40 Meter lab lasers must take new employment entrance and exit eye exams.

### **3.1 40 Meter Lab Standard Operating Procedure (SOP) for high-power IR laser (PSL)**

The 40 Meter Pre-Stabilized Laser contains a Class IV, high-power infrared (invisible) laser. A Class IV laser is a hazard to the eye or skin from the direct beam, may be a hazard from a diffuse reflection, and may also be a fire hazard. Infrared lasers such as the LIGO 10-W Laser pose an additional hazard because the output radiation is not visible to the unaided human eye.

To ensure the safety of all personnel working with or in the vicinity of the laser (in the Nominal Hazard Zone, which consists of the entire 40 Meter Lab experimental area), a Standard Operating Procedure has been instituted and documented in “LIGO 10-W Laser for the Interferometer Operating in the Caltech 40 Meter Laboratory”, LIGO-M010088-01-R, <http://www.ligo.caltech.edu/docs/M/M010088-00.pdf> . All 40 Meter Lab personnel are required to read, understand, and comply with all procedures described in that document.

During a LASER HAZARD condition (ie, whenever the laser is energized), the laser beam path must be fully enclosed within vacuum or optical table enclosures, with no openings through which the beams or scattered light could escape and potentially to a person’s eyes. During the times when work is actively being performed on the laser beam path, special precautions must be followed: scanning with IR viewer, working with at least two people present, awareness of and notification of all personnel working in the vicinity of the laser. All personnel and visitors must wear approved protective eyewear at all times while in the Nominal Hazard Zone, during the LASER HAZARD condition.

All concerns about laser safety should be reported immediately to the 40 Meter Lab Safety officers: Steve Vass, Bob Taylor, and to the trained laser operators, whose names are posted at the PSL enclosure.

### **3.2 Highlights of the PSL SOP**

All 40 Meter personnel should be completely familiar with all aspects of the Laser Standard Operating Procedure, including the following:

- Layout of the lab. The laser *Nominal Hazard Zone (NHZ)*.
- Laser description, special hazards.
- Laser safety conditions: LASER SAFE, LASER HAZARD, and LASER HAZARD - DOORS OPEN.
- Location and operation of emergency OFF switches.
- Required eye protection.
- The Responsible Laser Operator

- Procedures for transition to/from LASER HAZARD, and LASER HAZARD - DOORS OPEN conditions, including scans with the IR viewer, Operator's Log, use of alarm bypass and warning lights.
- Maintenance of the Operator Log.
- No one should energize or work with or near the 40 meter laboratory 10-watt laser unless authorized to do so. All persons operating the laser must have completed laser safety training and be registered with the LIGO Laboratory as specified in LIGO-M960001-B-P. All persons operating the laser must be familiar with all operating procedures, including emergency service procedures, emergency phone numbers, etc.

## 4 Electrical systems

High-power and high voltage electrical systems are a potential safety hazard, as well as a potential hazard to laboratory equipment.

All 40 Meter personnel should be familiar with:

- The location of all electrical breaker panels in the lab, including the office area, South Annex, and main experimental hall.
- How to shut off main power breakers in case of emergency.
- The location of the isolation transformers which supply conditioned power to the PSL and to the electronics racks.
- The locations and proper use of the rack power disconnect switches.
- The locations and safe operation of all high voltage and/or high power systems. Currently, these consist of: Ion pumps, STACIS, EOSs, PZT mirrors.
- The locations and operation of all halon fire extinguishers.

Electrical systems present a fire hazard. In order to respond effectively to electrical fires, while minimizing damage to the electrical equipment, Halon fire extinguishers should be used in case of electrical fires.

High voltage exists in only a few places in the laboratory: the Electro-optic shutters (EOSs) on the optical tables; the PZTs on the steering mirrors on the PSL table and in the BS chamber; the vacuum ion pumps next to each test mass chamber; and the STACIS seismic isolation systems mounted around each test mass chamber. Due care should be exercised when working with or near any of these devices.

Rack power disconnect switches are mounted nearby each rack, to be used in case of fire or other emergency. The rack chassis and instruments are grounded through these switches, and the ground connection is maintained even when the disconnect switches are used to interrupt power. All electrical devices on optical tables (including those in the vacuum enclosure) are grounded via cables to the rack ground. The optical tables are grounded to the vacuum enclosures.

In case of any problems, personnel safety is paramount. If there are no dangers to personnel, care should be taken to protect the electrical equipment. Detailed procedures for shutting down and bringing up all 40 Meter Lab electrical and computer systems are in the 40 Meter Procedures Manual. These procedures should be followed rigorously and carefully. The Manual is a living document that should be promptly updated when there are any discrepancies or new information or systems.

## 4.1 Lockout / tagout procedures

Working on high-power and high voltage electrical systems is a potential safety hazard. Work that requires a system to be de-energized (by switching a breaker, power switch, or unplugging) is vulnerable to the danger of someone else re-energizing the system without knowing that work is being performed. To ensure that this cannot happen, the Lab has a lockout / tagout procedure.

All equipment marked with the sticker below will be subject to this Lock-out/ Tag-out Procedure.



Locks or tags must be used to prevent inadvertent re-energizing of any of the following systems:

- PSL table enclosure
- Electrical breaker panels
- Rack disconnect switches
- Crane controls
- Ion pump HV
- Vacuum pump power
- Oven heaters in South Annex bake lab

All work will be performed by qualified personnel or under supervision of qualified personnel. Before beginning work the following must be done:

1. Fill out the Lock-out log located to the left of the double door in the control room, that leads into the 40m vertex area.
2. Obtain the proper LOCK-OUT device, with lock and key, for the equipment you will be working on.
3. Inform personnel of the work to be done and time that it will take to perform the work.
4. If working on very high voltage circuits, have an other person stand by for safety.
5. Turn circuit off, unplug or de energize the equipment.
6. Check to be sure that it is in fact turned off.

7. Tag and lock the circuit out with your NAME and DATE and keep the key to the lock on you. **Do not give it to someone to hold for you**
8. Personnel working in the area shall not remove, energize or in anyway tamper with a locked and tagged circuit. Only the person whose name appears on the tag may change the status of a locked out circuit.
9. If the work being done will take more than a day or if the person doing the work has to leave the area for a period of time the wiring will be left in a safe or protected manner.
10. When work is completed on a circuit, the equipment will be checked to see that there is no personnel in the way, before energizing the equipment.
11. Remove the LOCK-OUT devices and tags
12. Energize the circuit and check the equipment for proper operation.
13. Fill out the LOCK-OUT log ( Work completed and Date)
14. Stow the Lock-out devices properly. **( DO NOT FORGET TO PUT THE KEY ON THE LOCK CARD WITH THE LOCK)**

All 40 Meter Lab personnel must be instructed in the use of these lockout / tagout procedures during the regular safety briefings. These procedures are mandatory for all personnel working with de-energized systems.

## 5 Vacuum systems

The 40 Meter Lab vacuum system is rather complex, with potential hazards to personnel and to equipment. The 40 Meter vacuum envelope is large (32,000 cuft), and normally held at high vacuum ( $10^{-6}$  torr or  $10^{-9}$  atmosphere). There are numerous optical ports made of ½”-thick glass. These are nominally *all* protected by metal covers. The glass ports can break, and the broken vacuum volume can cause significant destructive force. Extreme care should be taken at all times while working around the vacuum ports, especially if the metal covers are removed for any reason! If you accidentally bump or scratch any of the glass ports, report this to a 40 Meter Lab staff member, so that the ports can be carefully inspected for even tiny amounts of damage.

The vacuum valves and pumps are controlled manually, using an EPICS computer interface. Only trained 40 Meter Lab vacuum system operators should use these controls; their names are posted on the vacuum controls computer by the vacuum controls rack.

As a general rule, at least two people (including at least one vacuum system operator) should be present when operating the controls, to minimize the chance of accidents or mistakes.

There are no special emergency procedures for the vacuum system. If an operator is available, the main volume valve V1 should be closed in case of some hazardous condition such as earthquake or fire. All other important vacuum valves are hardware- or software interlocked to automatically close in the event of power loss or software-defined unsafe condition.

The vacuum system is vented with N<sub>2</sub> up to 25 torr, then switched to instrument-grade air. The South Annex bake ovens are vented with N<sub>2</sub> up to atmosphere. When using N<sub>2</sub>, the hazard of asphyxiation exists (if the N<sub>2</sub> leaks significantly into the air). The area must be well ventilated at all times.

## 6 Hazardous chemicals

Hazardous chemicals are stored in cabinets in the 40 Meter entrance room and in the South Annex bake oven lab. Both cabinets are prominently labeled as FLAMMABLE and HAZARDOUS CHEMICALS.

Steve Vass and Bob Taylor maintain these cabinets and these hazardous materials. Anyone who requires their use must obtain prior approval from, and coordinate their activities with, Steve or Bob. Hazardous chemicals should be obtained from approved sources. Do not bring any hazardous materials into this laboratory without approval.

These two cabinets contain: turbopump oil, cleaning fluids (acetone, methanol, isopropyl alcohol, ethyl alcohol, liquinox, household cleaners, Protex mild inorganic acid), and liquid nitrogen for a bake oven LN2 trap. It should be noted that methanol and acetone are volatile chemicals that are poisonous if inhaled; they should only be used in well-ventilated areas. If more than a small amount of these chemicals are required, use them under a fume hood. The two fume hoods in the South Annex Lab should be running at all times, except under certain special circumstances.

## 7 Cranes and heavy objects

There are three cranes in the lab: in the vertex (BS chamber) area, at the east end (ETMX chamber), and at the south end (ETMY chamber).

Only certified crane operators may operate the cranes. The names of the certified crane operators are posted on all three crane controllers.

- Only the above-named trained crane operators, or trained repair or safety personnel, may operate the crane.
- Steel-toed safety shoes must be worn by all personnel working in the vicinity of the crane.
- Never operate the crane alone.
- Pay special attention to the cable winding so that it does not overcross.
- Visually inspect all equipment, especially lifting slings and harnesses, prior to operation.
- Always be fully aware of crane operation procedures for safe operation.
- Always be fully aware of potential safety hazards or concerns.
- You are responsible for the identification of safety hazards.
- You are responsible for the development and coordination of procedures.
- You are responsible for complying with all requirements of the LIGO Safety Program.
- If any work is performed in the crane power supplies or electrical equipment, lockout / tagout procedures must be followed!

Proper safety precautions must be used whenever lifting heavy objects. Obtain help whenever attempting to lift anything more than 30 lbs. For more information, see the Caltech safety document [http://www.safety.caltech.edu/training\\_physhaz.htm](http://www.safety.caltech.edu/training_physhaz.htm).

## 8 Emergency procedures

### 8.1 Fire

Fire alarm horns with flashing lights, fire alarm pull switches, halon fire extinguishers, emergency lights, emergency laser kill switches are placed at all lab exits (including emergency-only exits at the east and south ends); see Figure 1 for locations. All fire extinguishers are Halon; there are no CO<sub>2</sub> or other fire extinguisher technologies in the lab.

In the event of a fire, follow standard Caltech emergency procedures.

A small fire can be extinguished without evacuation, however, readiness to immediately evacuate must be maintained in case the fire can not be controlled. Fire extinguishers should be used only by trained personnel. Never enter a room filled with smoke. Never open a door if it feels warm to the touch. Never enter a room containing a fire.

Activate nearest alarm (know the locations of all alarm pull switches!) and call **x5000**. Close doors to confine fire. Evacuate to a safe area. Use stairs, **do not use elevators**. Provide information to emergency personnel about the incident and the facility. Wait for Fire Department okay before reentering building. All personnel should gather in the parking lot near the northwest corner of the lab, for a head-count.

Fire alarms can be set off easily. If you are soldering and producing smoke, move work to a fume hood or other well-ventilated place.

If an alarm is activated, fire personnel will respond quickly (the nearest fire station is one block away on Del Mar Avenue). LIGO personnel should escort the fire personnel into the laboratory if it is safe. LIGO personnel must inform the firemen of lab hazards and equipment: Powerful invisible laser. Large-volume vacuum system with glass windows. Lots of electronics, with high voltage. Location of isolation transformers, rack power disconnect switches. Delicate and expensive optics. Equipment protection.

### 8.2 Earthquake

Follow standard Caltech procedures for earthquakes.

- Be prepared. Do not place heavy objects on high shelves or elsewhere where they could fall on heads during an earthquake. All cabinets, bookshelves, racks, or other heavy things should be bolted to the floor or walls.
- Stay inside. Remain calm and watch for falling objects. Do not rush for the exit.
- If it can be done safely, hit the Laser kill switch.
- Duck, cover, and hold. Take cover under a table or desk and hold on.
- Stay away from windows, overhead fixtures, tall objects, and electrical equipment.
- If no cover is near, duck and hold near an interior wall. Shield your head and face from falling debris
- If outside, move to an open area away from buildings, trees, utility wires, and overhead structures.

### **8.3 Flooding**

In the past, there has been some flooding at the 40 Meter lab after a big rain. Since repairs in 2001, there have been no instances of flooding.

Should flooding occur, there is the hazard of electrical power malfunction. Alert the 40 Meter Lab safety officers. If necessary, kill the electrical power in the area. Stay away from a potentially dangerous situation.

### **8.4 Utility failures**

In the event of power failures, battery-powered emergency lights will illuminate the laboratory areas.

The laboratory contains a great deal of delicate laser, electrical, computer, and vacuum systems. In the event of loss of power, these systems should be powered down in a controlled and careful way. When power is restored, these systems should be turned on in a controlled way. Detailed procedures for shutting down and bringing up all 40 Meter Lab laser, electrical, computer, and vacuum systems are in the 40 Meter Procedures Manual.

### **8.5 Emergency evacuation**

The common meeting place for all 40m personnel is in the parking lot near the northwest corner of building. All personnel working in the lab should gather there during an emergency, for a head-count.

There is an eye wash and water shower station just across the way from the 40m lab main entrance.

## 9 Special cautions for the 40 Meter Lab

Let's review some of the special safety-related concerns in the 40 Meter lab:

- Large-volume vacuum system with glass viewports.
- High-power IR (invisible) laser.
- High voltage and high power.
- Booties can be slippery.
- Cables or equipment that are not secured and could be tripped over.
- South Annex bake ovens can be hot.
- Hazardous chemicals such as methanol and acetone.

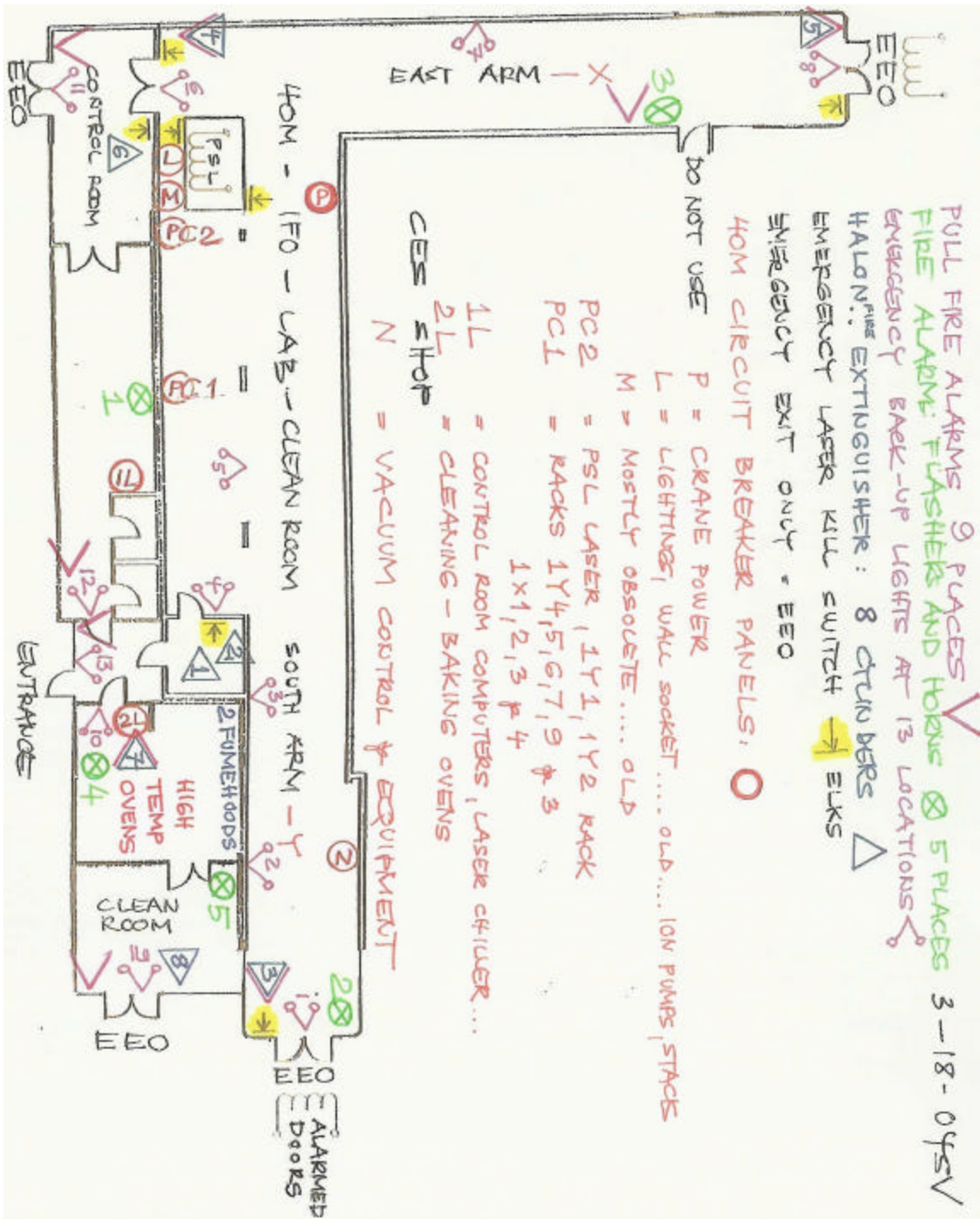
The South Annex bake oven lab contains numerous vacuum bake ovens. These ovens have powerful heaters which can get hot to the touch and which present a fire hazard. Care must be taken to avoid burns.

The ovens also have vacuum systems, and standard vacuum safety procedures must be followed. The lab also contains hazardous chemicals in a special cabinet marked **FLAMMABLE** and **HAZARDOUS CHEMICALS**. The two fume hoods in the South Annex should be running at all times.

If you have any personal health or other issues which are relevant for laboratory safety, please inform the 40 Meter Lab Safety Officers.

All laboratory visitors, including repairmen, firemen, etc, must be escorted at all times by a 40 Meter laboratory staff member.

Always remember that **HUMAN SAFETY IS NUMBER ONE**. You are responsible for your safety and for the safety of all other people in the lab. The safety of the laboratory equipment or any material possessions is always of secondary importance.



**Figure 1: Layout of 40 Meter Lab, showing locations of fire alarms, emergency lights, fire extinguishers, laser kill switches, emergency exits, and circuit breaker panels.**

# 40 Meter Lab Crane Operation

Trained crane operators as of April 2004:

- Steve Vass
- Bob Taylor
- Osamu Miyakawa
- Rob Ward

Important reminders:

- Only the above-named trained crane operators, or trained repair or safety personnel, may operate the crane.
- Steel-toed safety shoes must be worn by all personnel working in the vicinity of the crane.
- Never operate the crane alone.
- Pay special attention to the cable winding so that it does not overcross.
- Visually inspect all equipment, especially lifting slings and harnesses, prior to operation.
- Always be fully aware of crane operation procedures for safe operation.
- Always be fully aware of potential safety hazards or concerns.
- You are responsible for the identification of safety hazards.
- You are responsible for the development and coordination of procedures.
- You are responsible for complying with all requirements of the LIGO Safety Program.
- If any work is performed in the crane power supplies or electrical equipment, lockout / tagout procedures must be followed!

# EMERGENCY INSTRUCTIONS

**IF SMOKE OR FIRE IS PRESENT  
DO NOT ENTER THIS ROOM  
PULL THE FIRE ALARM LOCATED AT THE  
RIGHT OF THE BUILDING EXIT DOOR AND  
LEAVE THE BUILDING.**

**IF POSSIBLE CALL X-5000 AND REPORT THE PROBLEM**

**TO SHUT OFF MAIN POWER FOR THE BAKE OVEN LAB.  
GO NEXT DOOR TO CES SHOP MEZZANINE AND TURN  
OFF **MCC D SWITCH #11 IN PANNEL 2L****

**NON FIRE EMERGENCY  
CONTACT PHONE NUMBERS:  
STEVE VASS 626-355-9780  
BOB TAYLOR 626-355-6040**

## **40 Meter Lab Safety Officers:**

- Steve Vass
- Bob Taylor

## **40 Meter Lab Pre-Stabilized Laser Operators:**

- Steve Vass
- Osamu Miyakawa
- Rob Ward

## **40 Meter Lab Vacuum Controls Operators:**

- Steve Vass
- Osamu Miyakawa
- Bob Taylor
- Alan Weinstein

## **40 Meter Lab Crane Operators:**

- Steve Vass
- Osamu Miyakawa
- Bob Taylor
- Rob Ward

# HAZARDOUS CHEMICALS

(including methanol and acetone)

Use requires authorization from:  
Steve Vass or Bob Taylor

Hazardous chemicals must be obtained from approved  
sources.

Do not bring any hazardous materials into this laboratory  
without approval.