Argonne National Laboratory

Standard Operating Procedures For

Laser Controlled Area

Building 400, 7-ID-D
MHATT/XOR

version 6.0 (November 2004)

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AOD Division Director:

William Ruzicka
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Introduction, Roles, and Responsibilities

The laser controlled area (LCA) covered in this document consists of hutch 7-ID-D at the Advanced Photon Source (Building 400). The room contains a Class IV Ti:Sapphire laser system consisting of several individual Class IV laser components which may be used either separately or together as part of a larger system for any given experiment.

PURPOSE

The purpose of this LCA is to provide a re-configurable laser system for use in combined laser / synchrotron x-ray experiments. These experiments change on a weekly basis because they are assigned access to the laser system by General User and Partner User proposals at APS.

LCA SUPERVISOR

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The LCA Supervisor is responsible for the generation and delivery of laser light with the requested characteristics (wavelength, pulse duration, diameter, energy, and power) to User experiments. The LCA Supervisor is also responsible for documentation, maintenance, and safety issues associated with this laser system. It is anticipated that the specific needs of Users will vary daily as experiments are conducted, and that the LCA Supervisor will determine how to safely meet these demands during experiments. Authorized Laser Users (described below) may be involved with the operation of the laser system, but the LCA Supervisor must be involved in building and inspecting all laser setups. At the discretion of the LCA Supervisor, “laser only” experiments not requiring x-rays may also be conducted in the LCA.

The LCA Supervisor is appointed by the Director of the Experimental Facilities Division. Appointment of a new or deputy/interim LCA Supervisor requires notification of the LSO and the Division Director.

AUTHORIZED LASER USERS

An individual must be an Authorized User or “Operator” in order to perform any of the following tasks:

1. Turn on any Class III or IV laser
2. Align any Class III or IV laser
3. Insert, remove, or tweak any optical component in or near the laser beampath or similarly adjust any laser beam block or laser shielding
4. Assist the LCA Supervisor in delivering laser beam to an experiment

No person is allowed to operate the laser system in the LCA unless all three of the following requirements are met:

1. Permission from the LCA Supervisor, Eric Landahl;
2. Completion of the laser user eye examination approved by ESH Medical Department and the ANL Laser Safety Office;
3. Completion of appropriate safety training from APS and MHATT/XOR, as well as an approval from the APS User's Office to have an access to the experimental floor.
4. Signature of the Authorized User list posted at the LCA entrance (Apppendix B) and notification of the ANL LSO by the LCA Supervisor.

All Users must be re-authorized every time this SOP is updated. The only exception to these rules will be for Authorized Laser Service Personnel, described below.

AUTHORIZED LASER SERVICE PERSONNEL

Qualified personnel certified by laser manufacturers may be sent to Argonne to perform service work on any of the lasers or laser subsystems in the LCA. In addition to fulfilling APS requirements for mini-contractor training, a Job Safety Analysis must be approved before the work begins. Due to the complicated nature of this type of laser maintenance, which must be done at least in part at full power, an Authorized Laser User must be present any time that laser beams are exposed during the servicing to ensure compliance with ANL laser safety procedures. Authorized Laser Service Personnel are only authorized to conduct maintenance and repair procedures and will not be involved in beams delivered beyond diagnostics located at the output of the laser(s) under repair.

SCIENTIFIC COLLABORATORS

A Scientific Collaborator is allowed in the LCA during laser operations for scientific work not involving laser alignment only if approved by the LCA supervisor and if accompanied by an Authorized User at all times. Everybody in the LCA needs to wear proper eyewear approved by the LCA supervisor for the specific conditions of a given experiment when the laser beams are accessible. Scientific Collaborators must become Authorized Laser Users (see above) before touching any optical components.

SPECTATORS

Spectators are only allowed to enter the LCA in the presence of authorized users if the laser is off or the laser shutters are closed and no laser light is accessible.

Description and Normal Laser Operation

SYSTEM DESCRIPTION:

The laser system inside the LCA consists of four parts as described in Table 1.: A Ti:Sapphire oscillator (2) pumped by a frequency doubled Nd:YVO4 laser (1), plus a Ti:Sapphire amplifier (4), pumped by a frequency doubled Nd:YLF laser (3).
The laser system can be on, shuttered, or off. In the on state, laser beams are accessible and only authorized personnel as described above are allowed in the room. In the shuttered state, the laser is powered on, but physically prevented from emitting light; all laser light is physically contained inside the system and cannot be accessed. Even if a cover were to be removed from a shuttered laser, internal interlocks supplied by the manufacturer would prevent exposure.

In the off state, the laser power is off and no laser light is produced.

TABLE 1.: LASER INVENTORY

1. CW Diode Pumped Nd:YVO Laser
   ANL ESH IHID # 10395 Serial # V5-A6795
   Manufacturer: Coherent Model: Verdi
   Output: 532nm, CW
   Beam diameter: 2.25mm TEM_{00} Beam divergence: 0.5mrad
   Average power: < 5.5 W

2. Ti:Sapphire Oscillator
   ANL ESH IHID # 10396 Serial # 063
   Manufacturer: K&M Labs Model: short pulse oscillator
   Output: 750-850nm, pulsed (repetition rate 88 MHz)
   Pulse width (FWHM): 20fs – 200 ps, also CW (reconfigurable)
   Beam diameter: 0.8mm Beam divergence: 1 mrad
   Average power: <500mW pulsed, <1.0W in CW mode

3. Q-switched Nd:YLF LASER
   ANL ESH IHID # TBD Serial #2196167A
   Manufacturer: Coherent Model: Evolution 30
   Output: 527nm and 1054nm, pulsed (repetition rate 1-10kHz)
   Pulse width (FWHM): 200ns
   Beam diameter: 2mm (multimode) Beam divergence: 5 mrad
   Average power: 30W at 527nm, less than 500mW residual at 1054nm

4. Ti:Sapphire Amplifier
   ANL ESH IHID # TBD Serial #203241-01
   Manufacturer: Coherent Model: Legend HE USP
   Output: 750-850nm, pulsed (repetition rate determined by item 3: 1-10kHz)
   Pulse width (FWHM): 35 fs – 200 ps (reconfigurable)
   Beam diameter: 3mm (near-TEM_{00}) Beam divergence: < 100μrad
   Average power: 3 W

Note: The oscillator (item 2) and amplifier (item 4) do not produce any output radiation if their respective pump lasers (item 1 and 3 resp.) are shuttered or not in operation.

The overall system diagram is show in Appendix A. The output of item 1 is used to pump the oscillator item 2 directly, the output of Item 3 will be used to pump item 4 directly. Item 2 provides a seed pulse to Item 4 for amplification. Pump and seed beams will be enclosed and shielded and will not be accessible or be manipulated during amplifier (Item 4) operation. Depending on the User's requirements, any or all beams might be exposed and delivered to an experiment at a given time; however, the output of Item 4 delivers the highest peak power and is the laser configuration requested by most Users.

EYEWEAR:

The eyewear worn for standard laser operation should provide an optical density (OD) of at least 4 at wavelengths of 750-850nm for protection against the Ti:Sapphire beams. The eyewear for alignment of the laser while the pump beams are exposed should additionally provide ODε2 at 514-532nm and 1054-1064nm, for protection against the green and residual IR laser beams from the Neodymium pump lasers.

Standard protective laser eyewear will be provided at the entrance to the hutch 7-ID-D. (The eyewear provided for Ti:Sapphire has ODε7 at 695-1200nm. The eyewear provided for Neodymium wavelengths has ODe2 or ODε6 at 514-532nm and 1054-1064nm.)

NOTE: For applications utilizing higher harmonics of the Ti:Sapphire laser the following eyewear must be used. When using 400nm light (2^{nd} harmonic) the use of the standard eyewear for Neodymium (ODe6) has sufficient coverage to block 400nm radiation. For laser applications requiring UV light (<280nm, 3^{rd}+ harmonic) the standard issue Ti:Sapphire eyewear is required, which is calculated to provide ODε4 or better at these wavelengths.

All laser protective eyewear will be inspected quarterly and the results will be recorded in a log sheet attached at the end of this SOP.

LASER HAZARDS:

The Class IV lasers in 7-ID-D produce visible (green) and invisible radiation (infrared around 800nm) with sufficient power or energy to cause retinal or other injury to the eye, in both direct or specularly reflected beams. Diffuse reflections of the beam can be hazardous. The lasers also have the potential to cause burns on the skin or ignite flammable material.

OTHER HAZARDS:

High voltage:
110VAC, single phase, 100W (power to items 1,2,4).

Methods to control hazards associated with operation of the laser

The procedures for alignment of the laser subsystems are documented in the manuals for the K&M Labs Ti:Sapphire oscillator and the Coherent Legend amplifier. During normal operation, Ti:Sapphire laser goggles must be worn; during laser alignment involving exposure

of the pump lasers beams, additional goggles for Neodymium laser protection must be worn (see eyewear section above). IR viewers, fluorescent cards, and tv cameras will be provided to view the laser beams while wearing eye protection. In general Class 2 lasers can not be used for alignment because of the wavelength-dependent alignment of this type of laser and the extensive use of dielectric coated mirrors. However, a Class 2 self-leveling laser is available to rough align periscopes. On the optical table, the beam path will be confined to a plane below the eye level for operators in a standing position. The laser beam must be brought up to x-ray height (~ 56 inches above the floor) for x-ray experiments; therefore, these unusually high beam paths should be carefully shielded and checked for stray reflections. Transport of laser beam between tables must be enclosed by opaque, non-flammable laser transport tubes.

The laser eyewear will be inspected quarterly and the results of the inspection will be recorded in the table attached at the end of this document.

ADDITIONAL CONTROL OF LASER HAZARDS

1. *LASER HAZARD WARNING SIGNS* are posted above the entrance door to the 7-ID-D and will be illuminated when the laser is on.

2. An *INTERLOCK SYSTEM* is installed at the entrance doors to the LCA, which automatically closes an internal shutter of the laser system upon an entry to the LCA by unauthorized personnel. A timed defeat switch is installed at the entrance for the authorized operators to exit/enter the LCA without interrupting laser experiments. Figure 2 shows the location of the interlocks and Figure 3 shows a summary of the interlock actions.

The interlock system will be inspected quarterly per the actions in Figure 3, and the results will be recorded in the log sheet attached at the end of this document. The door switch in 7-ID-D will be inspected to see if they fulfill the expected function.

3. *LASER SAFETY GLASSES* or other eye protection devices which provide sufficient attenuation of hazardous light intensities to prevent eye injury to the wearer shall be worn whenever such hazardous light intensities are present. Laser safety glasses will be provided at the entrance to the LCA. They will be inspected quarterly and the results will be recorded in the log sheet attached at the end of this document.

4. *LASER BEAM SHIELDS* are made of non-combustible laser beam stops, which will not create hazardous light airborne particulate matter when in use. The beam path is confined to a plane well below eye level and shielded as much as practicable.

5. *UNAUTHORIZED OPERATION* The Laser Power Supply Keys for the class IV laser will be switched to the disabled state while the laser is off and unattended. The master interlock shutter control key will be switched off in the disabled state. The keys will remain under administrative control while the laser is not in operation to prevent unauthorized operation of the laser.

5. *EMERGENCY LASER CUT-OFF SWITCH (Class IV)* Two panic switches are marked by large signs in red. These switches insert all laser shutters and turn off the electrical power that produces light in the diodes of lasers # 1 and #3.

STANDARD OPERATION PROCEDURES FOR HANDLING POSTULATED AND CREDIBLE ABNORMAL AND EMERGENCY CONDITIONS

In the events of:

1. Breakdown of a high voltage system Call 911 if help is needed, shut off power at main circuit breaker, and report to the LCA Supervisor.
2. Laser burns to eyes and/or skin Call 911, shut laser system down, report to LCA Supervisor and to the APS floor coordinator.
3. Laser coolant (water) accidentally discharged into the environment Shut laser system down, report to the LCA supervisor, and report to the APS floor coordinator to have the discharge cleaned up.
4. Fire and tornado In case of fire, call 911, quickly evacuate from the LCA and pull the nearest fire alarm. In case of tornado, evacuate immediately to the nearest tornado shelter (the restrooms at Building 433).

METHODS TO CONTROL HAZARDS ASSOCIATED WITH ALIGNMENT OF THE LASER AND THE LASER BEAM IT PRODUCES

During alignment of the laser in 7-ID-D, or operation which requires the presence of an operator, the automatic door to the hutch is kept open. Laser shielding (a curtain for shielding the laser beam) and a barrier sensor are installed at the 7-ID-D automatic door entrance which will not hinder the entry/exit for the operators. Other unauthorized personnel are not allowed to enter 7-ID-D during operation of the laser and are warned by the laser warning lights above the hutch door and a warning sign on the laser curtain. If the barrier sensor is blocked due to an entry through the curtain or the curtain is not closed in place, the laser shutters inside 7-ID-D will close, stopping any laser beam. Once inside the curtain, the authorized laser operator will be able to reopen the shutter by activating the laser shutter switch inside 7-ID-D. Light shielding is provided along the laser beam path inside 7-ID-D as much as possible.

Appropriate laser goggles must be worn in 7-ID-D at any time exposure to the laser beam is possible.

Alignment of the laser components will be performed with all beams turned to the minimum power necessary for the procedure. After alignment, all laser beams between laser components will be shielded from view and access by beam tubes and permanent shields as much as possible. Laser beam shields along the path of the output beam from the final amplifier will be installed where possible to minimize the possibility of laser beam exposure.

APPENDIX A

LASER TABLE LAYOUT

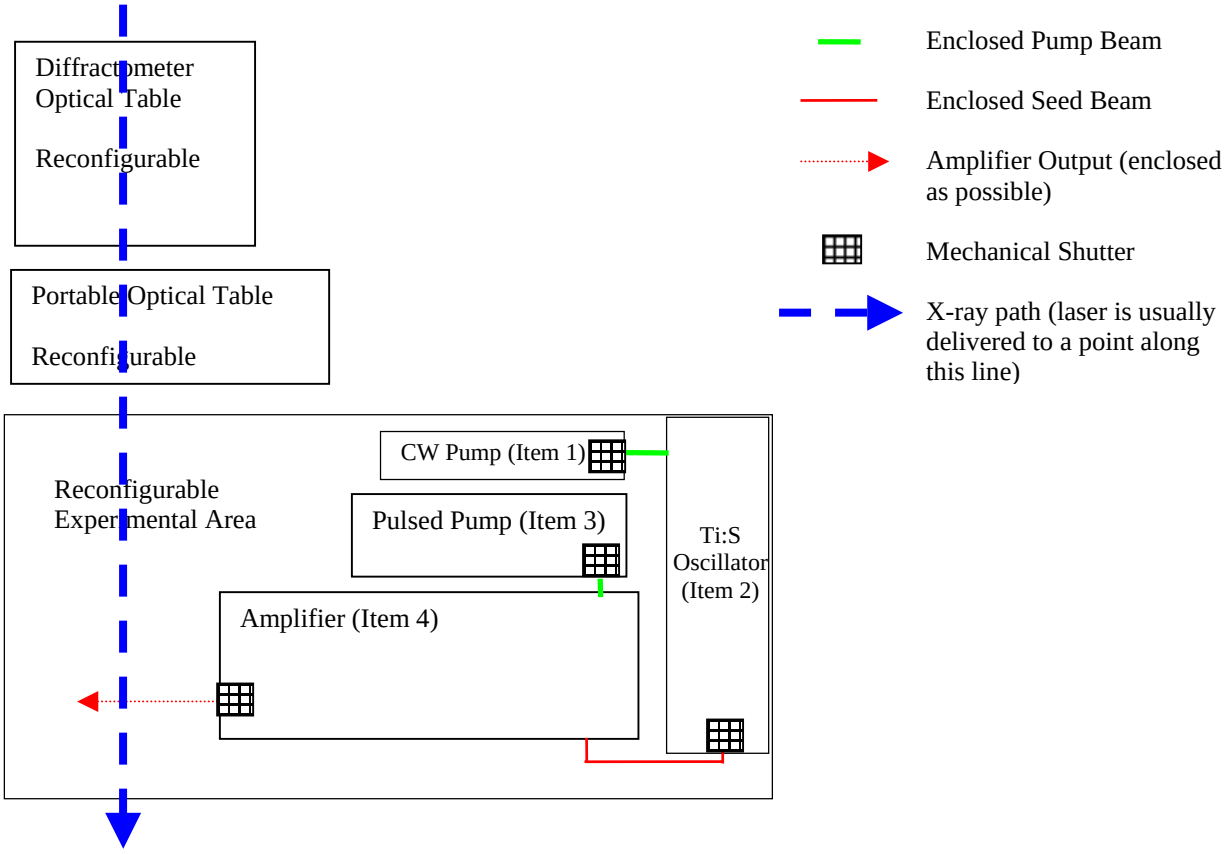

FIGURE 1

Floor Plan

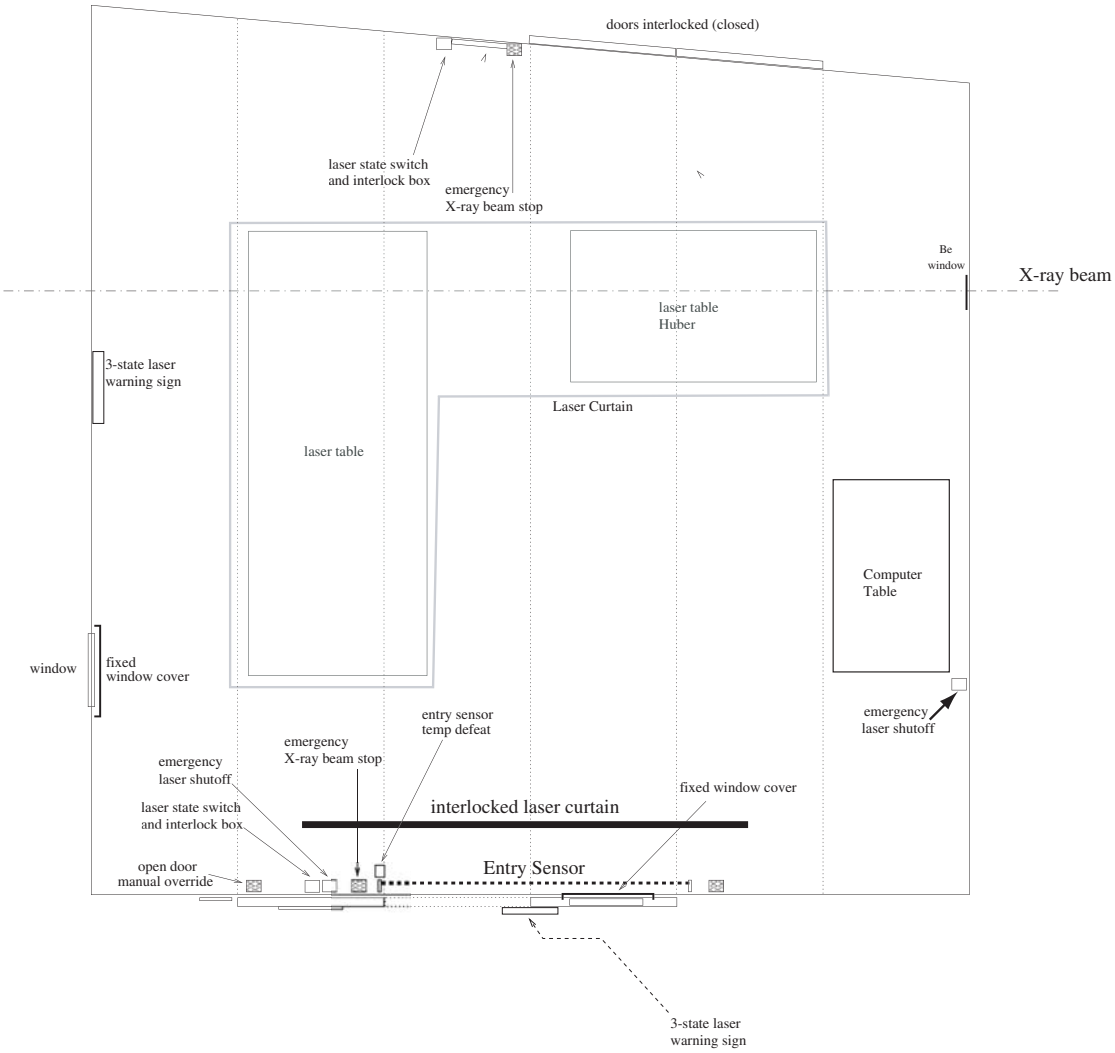

FIGURE 2

Interlock State	Emergency Laser Shutoff	Master Key	Back Door	Curtain	Entry Sensor *	Lid	State Request 1	2	3
3 Danger: Beams Accessible	**1**	**2**	**1**	**1**	**2**	**—**	**1**	**2**	**—**
2 Warning: Laser Energized	**1**	**—**	**1**	**1**	**1/—†**	**1**	**1**	**—**	**3§**
1 No Hazard: laser off	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**2§**	**—**

In state **3**., all shutters enabled.
In state **2**., only the Verdi is enabled—all laser light is contained.
In state **1**., all shutters are disabled.

***** The action of the entry sensor may be temporarily overidden by the timed bypass switch.
† System drops to state 1 if the Master Key is out, otherwise no action is taken.
§ Master Key is required to raise state.

In addition, all action that takes the system from state **3** to state **2** requires that the conditions for state 2 are met, otherwise the system will drop to state **1**.

FIGURE 3

APPENDIX B

(AUTHORIZED USERS, LASER EYE WEAR INSPECTION LOG, LASER INTERLOCK INSPECTION LOG)

AUTHORIZED USERS

List all Authorized Users, include their badge number. Users should sign the document to verify that they have read and understand the Standard Operating Procedure for the LCA.

7-ID-D

NAME (printed)	BADGE	SIGNATURE
ERIC LANDAHL	38579	

Laser Eye Wear Inspection Log:

Date of Inspection	Results	Inspector

Laser Interlock Inspection Log for 7-ID-D

Date	Result	Inspector