Argonne National Laboratory

HEP Division

Standard Operating Procedure For BLDG. 366 AWA Laser Room Laser Controlled Area

Version 2.0

March 6, 2007

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John Power March 7th 2007

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1. INTRODUCTION

The laser controlled area (LCA) is the AWA room in building 366. Only those specifically authorized by John Power, LCA Supervisor in the Accelerator Group in HEP, are to be permitted to operate the laser systems within this laser controlled area. Currently the only authorized users are identified in Appendix B.There is one main laser system in the LCA. This laser system is comprised of several optical subcomponents whose function, maintenance, and operation are outlined in this SOP. Therefore, it is imperative that all users follow this SOP, any deviations must be approved by John Power.

The old AWA laser system has been in operation for 10 + years and was replaced with an all solid state laser system in 2002. The purpose is to use the UV output of the laser to generate photo electrons from the AWA RF phothocathode guns. The designed laser output is (248 – 266 nm, 2- 5 mJ, 744 – 800 nm, 40- 80 mJ, 10 ps).

A diagram of the LCA floor plan is provided in Appendix A.

2. LCA SUPERVISOR

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3. SCIENTIFIC COLLABORATORS & SPECTATORS

This section addresses the safety of three classes of non-authorized users in the LCA - Scientific Collaborators, Spectators, and Visitors.

Scientific Collaborators:
Below are the responsibilities pertaining to Scientific Collaborators found in the CHM Laser Safety Manual. A Scientific Collaborator is defined as someone who is not a laser user and has no direct control over the laser beam, but participates in the experiment in some other capacity.

Scientific Collaborator Responsibilities

1. A scientific collaborator shall not be permitted to control any laser beams (such as by an external optical element) and shall not handle or manipulate any laser in the LCA.

2. A scientific collaborator shall never be alone in the LCA. An authorized user shall be present and supervise all activities of the scientific collaborator within the LCA.

3. A scientific collaborator shall not be present while a laser is being aligned.

4. A scientific collaborator shall only be present in the LCA when the beam is enclosed and maximum protection, e.g., eyewear, is in use as designated in the SOP.

5. The actions and safety of a scientific collaborator within the LCA are the direct responsibility of the LCA supervisor.

6. Depending on the nature of their participation, and upon specific approval by the LCA supervisor, scientific collaborators may be offered the opportunity to take the ESH120 course.

Spectators:
A spectator is defined in the Laser Safety, Section 6.2 of the ANL ESH manual as an individual who observes or watches a laser or laser system in operation, and who may lack appropriate safety training or medical screening. The spectator will not be operating any laboratory equipment. The spectator will not be in close proximity to the beam. The spectator must be provided with protection, e.g. eyewear and laser enclosure. Only spectators approved by John Power will be allowed in the lab. Spectators will be required to wear the maximum eye protection that is available at all of the laser wavelengths (248 nm-266nm, 532nm, and 744nm-800nm).

Spectator Responsibilities:

1. A spectator shall never be alone in the LCA. An authorized user shall be present and supervise all activities of the spectator within the LCA.

2. A spectator shall not be present while a laser is being aligned.

3. A spectator present in the LCA shall be provided maximum protection, e.g., eyewear and system enclosure, as designated in the SOP.

4. The actions and safety of a spectator within the LCA are the direct responsibility of the LCA supervisor.

Visitors:
A visitor is defined as any person who is not an authorized user, scientific collaborator, or spectator or any person who has no official need to see the laser system in operation. The visitor classification would apply to all individuals who are touring or inspecting laboratories. All lasers will be turned off or completely enclosed while visitors are present in the LCA.

Visitor Responsibilities

1. A visitor is allowed in an LCA only when the laser circuitry is disabled.

2. The actions and safety of a visitor within the LCA are the direct responsibility of the LCA supervisor.

Work performed by ANL-PFS in the LCA (plumbers, electricians, custodians, etc.) will be done with all lasers off.

4. NORMAL LASER OPERATION AND SURVEY OF AWA LASERS

The laser system is an amplified Ti:Sapphire system that is for use as a laser electron accelerator. It consists of a CW "neodymium yttrium vanadate" Nd:YVO (532nm, <5W CW) pumped Ti:Sapphire oscillator (100 fs, <10nJ, 80MHz, 744 or 800 nm) that is used to seed a three stage amplifier chain. Before the amplifiers, the pulses are passed through an optical pulse stretcher that increases the pulsewidth to 60-350ps. After amplification, the laser is passed through an optical compressor that reduces the pulselength to ~10 ps before entering the THG box, which has UV (248 or 266 nm) output of 2 –3 mJ/pulse. The entire laser system is contained in a light tight enclosure that is continuously purged with HEPA filtered air.

Normal laser operation is defined as operation with **NO** exposed IR or green laser beams. This mode of operation of the laser system occurs after it has been warmed (or 'tweaked') up and all of the IR and Green beam enclosures have been sealed.

Prior to this state (i.e., during the tweak-up) it should always be assumed that there may be an exposed beam present and the appropriate eyewear is to be worn at all times by all persons in the LCA. No exceptions. During warm-up it is the responsibility of the laser operator to indicate the potential hazards to any other authorized users that are present. If an authorized user wishes to enter the LCA while the Laser Repair sign is posted they are to either ring the LCA doorbell (red button located ~1.5m to the right of the LCA door) or yell through the door. No entrance into the LCA is to be made until the laser operator informs the user of the work that is in progress. The specifics of the warm-up and alignment procedures will be discussed in Section 6.

Table 1 provides a list and pertinent characteristics of the commercial Class IV lasers that are present in the AWA LCA. This is followed by a more detailed description of each laser, including eyewear to be worn. The specific types of eyewear are defined in Section 5. Appendix A shows how the lasers are arranged in the LCA.

Table 1. Commercial Active Type IV Lasers Present AWA Laser Room. Refer to figure in Appendix A for laser layout.

Laser	Manufacturer/Model	Function	Output
#1 100 MHz Ti:Sapphire Oscillator	Spectra Physics Tsunami	Provides seed pulses for TSA	10 nJ, 25 fs, 744nm-800nm, 100 MHz
#2 CW Nd:YVO	Spectra Physics Millenia V	Ti:Sapphire Oscillator Pump	5W, CW, 532nm
#3 10Hz Nd:YAG	Spectra Physics LAB-170	Pumps REGEN & linear Amp#1 for TSA 50	10Hz, 10ns, 532nm, 300mJ
#4 10Hz Nd:YAG	Spectra Physics PRO-230	Pump for linear Amp#2 for TSA 50	10Hz, 10ns 532nm, 500mJ
#5 10 Hz KrF Excimer	Lambda Physik LPX 105i	UV Amp	10 Hz, 10 ps 248 nm, 8 mJ

SURVEY OF AWA LASERS

LASER #1

Mfr. Spectra Physics Model Tsunami Class IV
ANL # P069239 S/N 1473GR Type Ti:Sapphire
IHID 10525

OPERATING PARAMETERS

CW Power: 0.5W (Normal): 0.5W(800nm) W (Max)
Pulse: Energy 10nJ Width 25fs
Peak Power 20MW PRF 100MHz
Beam Dia. 2.5mm Divergence .5 mr
Wavelength(s) 720-860nm

Use: seed for Ti:Sapphire amplifier system
Hazardous Materials: n/a
Enclosures/Shields: manufacturer's cover
Access Control: passive: pumped by Spectra Physics Millenia V
Eye Protection: **cover off** (800nm and 532nm present) Type 1 (UVEX LOTG-YAG/KTP)
cover on (only 800nm present) Type 2 (UVEX LOTG-YAG/CO2)

LASER #2

Mfr. Spectra Physics Model Millenia V Class IV
ANL # P069238 S/N 1634R Type Nd:YVO
IHID 10524

OPERATING PARAMETERS

CW Power: 5W (Normal); 5.5W(532nm) (Max)
Pulse: Energy N/A Width N/A
Peak Power N/A PRF CW
Beam Dia. 2.5mm Divergence .5 mr
Wavelength(s) 532nm

Use: pump for a Tsunami Ti:Sapphire oscillator
Hazardous Materials: n/a
Enclosures/Shields: manufacturer's cover
Access Control: active coupled to door interlock system
Eye Protection: **cover on:** Type 1 goggles: UVEX LOTG-YAG/KTP. (532nm protection)

LASER #3

Mfr. Spectra Physics Model LAB-170 Class IV
ANL # P069240 S/N 1961L Type Nd:YAG
IHID 10522

OPERATING PARAMETERS

CW Power:3W (Normal): 3.2W(532nm) W (Max)
Pulse: Energy 300mJ Width 10ns
Peak Power 30MW PRF 10Hz (max)
Beam Dia. 10mm Divergence .5 mr
Wavelength(s) 532nm

Use: pump for a multipass Ti:Sapphire regen amplifier and two-pass linear amplifier#1
Hazardous Materials: n/a
Enclosures/Shields: manufacturer's cover
Access Control: active: coupled to door interlock
Eye Protection: **cover on:** Type 1 goggles: UVEX LOTG-YAG/KTP. (532nm protection)

LASER #4

Mfr. Spectra Physics Model PRO-230 Class IV
ANL # P069241 S/N 1960PR Type Nd:YAG
IHID 10523

OPERATING PARAMETERS

CW Power: 5W (Normal): 5.5W(532nm) W (Max)
Pulse: Energy 500mJ Width 10ns
Peak Power 50MW PRF 10Hz (max)
Beam Dia. 10mm Divergence .5 mr
Wavelength(s) 532nm

Use: pump for a Ti:Sapphire two-pass linear amplifier#2
Hazardous Materials: n/a
Enclosures/Shields: manufacturer's cover
Access Control: active: coupled to door interlock
Eye Protection: **cover on:** Type 1 goggles: UVEX LOTG-YAG/KTP. (532nm protection)

LASER #5

Mfr. Lambda Physik Model LPX 105i Class IV
ANL # P062064 S/N 9108E3370 Type KrF
IHID 10378

OPERATING PARAMETERS

CW Power: .0.08 W (Normal): 0.1 W (Max)
Pulse: Energy 8 mJ Width 10 ps
Peak Power 0.8 GW PRF 10 Hz
Beam Dia. 1cm Divergence .5 mr
Wavelength(s) 248 nm

Use: Amplify the output laser pulse from THG
Hazardous Materials: KrF premixed gas
Enclosures/Shields: manufacturer's cover
Access Control: Active: Door interlock
Eye Protection: **cover on:** all 3 goggles in Table 3 are sufficient, LaserShield clear UV Goggles

Notes:
Authorized laser users should avoid accidental contact (eye or skin) with laser radiation by closing the output beam shutters when the beam is not in use, by arranging the optics and beam blocks for a given experiment to keep all laser beams and reflections on the optical table and by wearing appropriate eye wear. Three sets of laser goggles are kept in the lab for protection against all wavelengths.

5. EYEWEAR SECTION

The ANL Laser Saftey Officer has recommended that the following OD number for each lactive laser specified in this SOP. The eyewear is to be inspected quarterly for damage or deterioration. Further details on eyewear that is to be worn during alignments is in section 6. Calculations for eyewear is done by ANL LSO.

Table 2. OD requirement for the lasers in the AWA LCA

Type	Lasers	Wavelengths (nm)	OD	Lens Color
A	LAB-170, PRO-230	532	6+	Brown
B	Tsunami	700-1200	3+	Brown or Green
C	Milenium V	532	4+	Brown
D	LPX 105i	248-266	6+	Brown, Green, or Clear

Table 3. Types of goggles* used in the AWA LCA

Type	Brand	Type	OD@ Wavelengths (nm)
1	UVEX	Brown LOTG-YAG/CO2	OD=7@190-532 OD=3+ @ 800-839.
2	UVEX	Green LOTG-YAG/KTP	OD=7 @ 190-380 OD=3+ @ 800-839
3	LaserShield	Clear	OD=6 @ 248

***All 3 types are hard goggles that fit over glasses**

Eyewear is to be inspected quarterly by the LCA supervisor for damage or deterioration and record the results in the log sheet. Dispose any goggles that may potentially have defects (loosa band, cracked frames, etc.).

6. ALIGNMENT HAZARD CONTROL

The type of alignment procedure used for the laser system development involves optimization of the laser output.

There are two main types of alignments.

1. Alignment/repair of the commercial lasers listed in Table 1.
2. Day-to-day optimization of the homebuilt amplifiers, this procedure uses 'minor' tweaks.

6.1 ALIGNMENT OF THE COMMERCIAL TYPE IV LASER SYSTEMS

All of the commercial systems listed in Table 1 require very little tweaking. All of these lasers are to be operated in accordance to their respective manuals. The manuals are located on the bookshelf shown in the figure of Appendix A. The Spectra Physics Millenia V requires no adjustments at all.

Occasionally it is necessary to check the output power of the pulsed Nd:YAG lasers. This is done by first putting on the appropriate eyewear (Section 5), placing a power meter at the laser output and then turning on the laser. When optimizing the laser output the eyewear described in section 5 must be worn. The output of the laser is to be monitored with a power meter and a photodiode, therefore, there is **no** need to 'see' the laser beam. Internal alignment (optimization) of each commercial laser is done according to the procedures in its respective manual, generally using a power meter. When the alignment is complete the laser covers are to be immediately replaced.

No spectators or collaborators are to be allowed in the LCA during an alignment.

6.2 DAY-TO-DAY ALIGNMENT (IR)

TYPE 1 (Brown, LOTG-YAG/KTP) or TYPE 2 (Green, LOTG-YAG/CO2) GOGGLES MUST BE WORN FOR THIS ENTIRE PROCEDURE, 744 - 800NM BEAMS ARE TO BE OBSERVED WITH AN IR VIEWER

Under normal conditions a small amount of tweaking is required on a day-to-day basis. This is mainly involved in TSA 50, which is a passive amplifier. Each subcomponent of the laser system is to be aligned as instructed in the TSA 50 operation manual which is located in the laser room.

During the alignment, it is absolutely necessary for users to wear appropriate goggles.

6.2 DAY-TO-DAY ALIGNMENT (UV)

TYPE 3 (LaserShield Clear) GOGGLES MUST BE WORN FOR THIS ENTIRE PROCEDURE, 248 and 266 NM BEAMS ARE TO BE OBSERVED WITH A UV CARD OR KENTEK UV VIEWER

Some day-to-day alignment of the UV laser is required for the AWA experiments. The nominal laser output at 248 nm is 20 mW from the THG and 80 mW from the KrF excminet laser. There are practical limitations of using the remote sensing alignment method due to difficult implementation and cost. Following procedure is to be followed:

Before any laignemnt work, a neutral density filtr must be placed at the THG output window to cut the laser <1mW or as low as possible. The same procedure also applies to the KrF eximenr laser when in use. This procedure will insure that minimal exposure of the UV beam during alignment. Laser goggles (type D) must be worn when performing this task.

When alignment is completed, make sure the laser beam enclosures are properly in place and secured. Then remove the ND filtrt and procede with the experiments.

During the alignment, it is absolutely necessary for users to wear appropriate goggles.

7. LASER HAZARD CONTROL

A laser hazard warning light system at the entrance to laser room indicates the operating status of the laser system. This warning light shall be maintained in good operating order and the interlocks shall be quarterly tested to ensure correct performance.

The entrance to the LCA is interlocked so that unauthorized entrance causes all active laser systems to shut down automatically. The door interlock defeat switch shall be used only by authorized laser users and then only when it is essential to avoid interruption on an experiment and it has been ascertained that no hazardous light will be emitted from the laser controlled area when the door is opened. An emergency power shutoff switches are located on the North wall of the LCA.

When the interlock system is tripped the Millennium, Lab 170 and Pro 230 pump lasers, and KrF amps are all shut off. Therefore there would be no more laser beam in the LCA.

The door interlock should be tested quarterly; both doors need to be checked. Opening either door should cause the interlock to drop. With either door open no, no laser would be able to turn on.

8. ADDITIONAL COMMENTS ON PPG AND INTENSE LASER BEAMS

Some important points about working with the 744- 800nm light. It is outside the visible spectral range and is therefore only possible to view it at high powers. 800nm is considered outside of the human visible response region. It should always be treated as invisible, even though under the extremely high powers present with this laser system it is possible to see a dim red beam. The dimness of the beam is deceiving; it is extremely hazardous and should be treated as such.

The procedure for the insertion of new optical components is as follows.

First, the optics to be aligned should be pre-aligned with the laser blocked. With the proper eyewear and the IR viewer the beam should be unblocked and its trajectory determined. This process is then reiterated until the proper alignment is achieved.

Second, for those situations when one must be able to see the beam and simultaneously use two hands we propose to use a head mounted IR viewing device to assist in those alignments that would otherwise require the use of three hands. This will provide adequate eye protection while enabling the operator to see the IR laser beam.

Third, the use of latex gloves is important. When the proper eyewear is worn the user is blind to all of the laser beams. As a consequence of laser optimization the beams tend to pass rather close to each other. It is possible to burn skin rather easily under these conditions. Leather gloves prevent this hazard. We use leather gloves with the finger tips cut off. This provides the necessary protection while maintaining the sensitive touch that is required for delicate adjustments.

9. CONTROL OF ADDITIONAL LCA HAZARDS

High Voltages: Life-threatening high voltages and /or currents are present in the laser power supplies and laser heads. These are interlocked for safety. Authorized users should always double check that the power is off before performing any repair work. If troubleshooting or maintenance requires defeat of the interlocks, two people must be present. In general, all repairs performed on the lasers described in Table 1 will be done by field technicians from the respective laser companies.

10. ASSOCIATED CHEMICAL HAZARD CONTROL

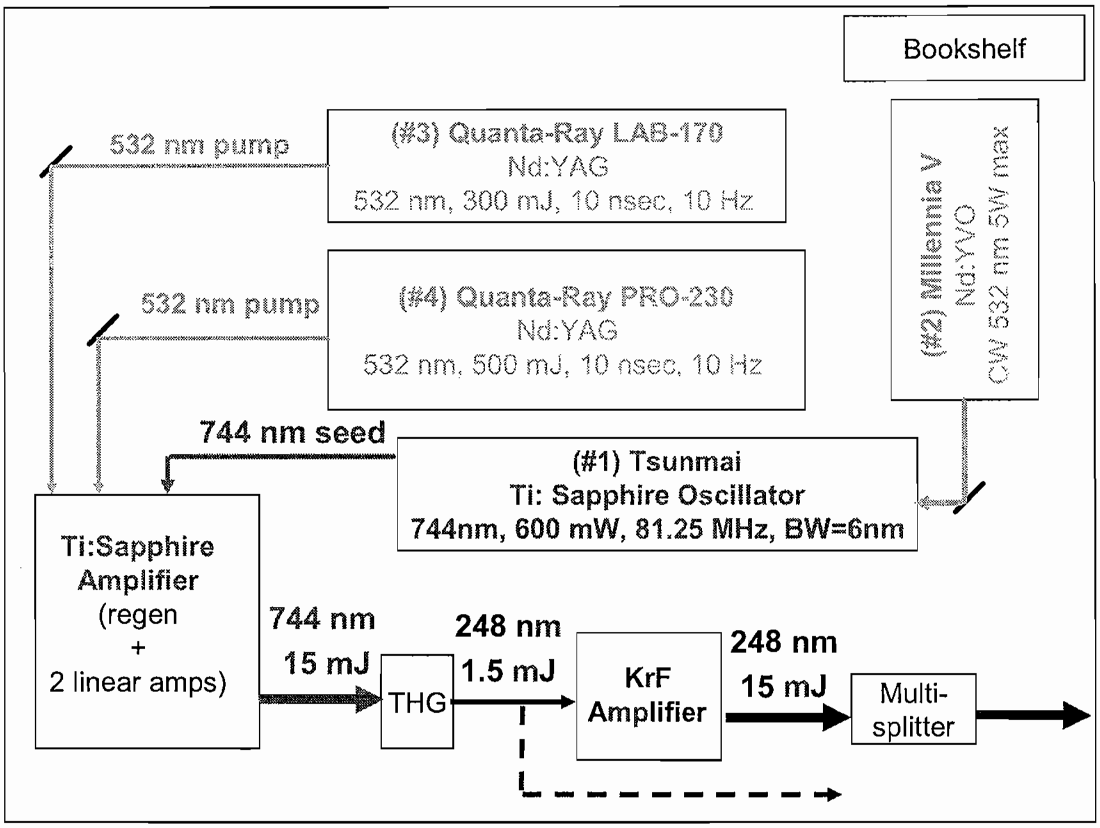
The Lambda Physik LPX 105i uses premixed laser gas which contains a small percent (<3%) of Flourine. The laser has been in use in the last ten years and its gas cylinder is contained in a commercial gas cabinet with exhaust fan attached to it. The laser is also vented to the building outside to prevent any accidental leaks. If the fan stops, a buzzer will sound to alarm the user to check the system.

11. CONTROL OF EMERGENCIES & ABNORMAL SITUATIONS

In the case of an outbreak of fire, chemical spill, laser burn, etc., or any other abnormal emergency which constitutes an imminent danger to personnel within the LCA, immediately evacuate the area and call 911.

Unauthorized laser operation will be prevented by keeping the door to AWA laser room access locked when authorized users are not present. Key access to the AWA rooms are limited to AWA personnel

APPENDIX A Diagram of AWA Laser Controlled Area 366



APPENDIX B

AUTHORIZED AWA USERS

Name	Badge
John Power	42699
Manoel Conde	47901
Filipe Franchini	
Wei Gai	34596
Chunguang Jing	
Marwan Rihaoui	
Zikri Yusof	

TEMPORARY AUTHORIZED USERS (see Appendix C)

Name	Badge
Yuelin Li	APS
Jinhao Ruan	FNAL
Cheng-Yang_Tan;	FNAL
Randy M. Thurman-Keup;	FNAL
Vic Scarpine;	FNAL
Tim Maxwell	NIU

APPENDIX C

LASER OPERATION FOR TEMPORARY LASER-BASED EXPERIMENT

The operation for an electro-optic (EO) experiment is described. The setup is placed near the exit of the TSA that uses the output of the TSA and a sub-sample of the oscillator. A Pockel cell is used to reduce the repetition rate of the oscillator from 81.25 MHz to approximetly 1 kHz, thus reducing the output power from 600 mW to 7 uW.

During the alignment/experiment, special control will be in place

1. A special sign will be in display outside the LCA when the experiment/alignment is in progress.
2. The alignment/experiment can be carried out only when at least one of the authorized laser users is present;
3. Besides the authorized users, no more than two other users can be present during the experiment at the same time;
4. Every collaborator in presence is required to use the designated PPE.
5. All collaborators shall respond immediately to the stop-work request of the LCAS and the authorized user in charge.
6. If any emergency occurs, the experiment/alignment should be immediately stopped and laser beam should be blocked or the laser be turned off, and the situation should be reported to the LCAS.
7. All alignment should be conducted according to the safety procedure described in Section 6, briefly
   a. Starting alignment with class II laser whenever possible
   b. If real laser has be used for alignment, use a low power mode when possible
   c. Block all potential hazardous optical port/window
   d. Enclose the beam whenever possible
   e. Use proper eyewear all the time when the laser is activated
   f. Use proper beam viewing device such as fluorescent cards or IR viewers

DESIGN OF AN ELECTRO-OPTICAL SAMPLING EXPERIMENT AT THE AWA FACILITY

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Abstract

The free space electro-optical (EO) sampling technique is a powerful tool for analyzing the longitudinal charge density of an ultrashort e-beam. In this paper, we present (i) experimental results for a laser-based mock-up of the EO experiment and (ii) a design for a beam-based, single-shot, EO sampling experiment using the e-beam from the Argonne Wakefield Accelerator (AWA) RF photoinjector. For the mock-up, a tabletop terahertz experiment is conducted in the AWA laser room. The mock-up uses an IR beam incident on <110> ZnTe crystal to produce a THz pulse via optical rectification. Detection is based on the cross correlation between the THz field and the probe IR laser field in a second <110> ZnTe crystal. Potential application of this technique to the ILC accelerator test facility at Fermilab is also presented.