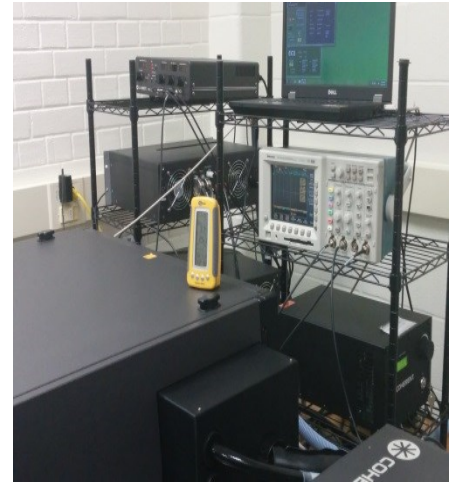


MME Standard Operating Procedure (SOP)

Name	Femtosecond Laser
Description	Coherent Legend Elite, Ultrafast Amplifier Laser Systems
Location	E3 -2168
SOP Creation Date	2015-03-08
SOP Created By	Paola Russo
SOP Revision Date	
SOP Revised By	
SOP Location	E3-2168
Manual Location	E3-2168
Equipment Owner	Dr. Norman Zhou
Authorized Trainers	Paola Russo
Support Technicians	Robert Letiecq (Coherent) Staff Service Engineer Tech support: 800-367-7890 Robert.Letiecq@coherent.com



<p>Significant Hazards</p>	<ul style="list-style-type: none"> • Exposure to laser beam and laser reflections (Vision protection) – Laser irradiation to eye • Laser radiation (wavelengths: 800 nm) • Eyes and Skin hazards <ul style="list-style-type: none"> ○ Thermal (heat build-up from absorbed laser light) ○ Photo-chemical (photon energy sufficient to cause bond breaking) • Laser hazards to the eye <ul style="list-style-type: none"> ○ Visible and near IR (400 to 1400 nm) ○ Absorbed at retina ○ Blind spots <ul style="list-style-type: none"> ○ Optic disk > total blindness ○ Fovea > central vision ○ Macula > color vision ○ Degraded color vision ○ Degraded night vision • Laser hazards to the skin (Visible to near IR) <ul style="list-style-type: none"> ○ Penetrates partially through skin ○ Deep burns • Non-beam hazards <ul style="list-style-type: none"> ○ Fire and explosion (class 4 lasers able to ignite combustible materials >> keep production area clean) ○ Compressed gases <ul style="list-style-type: none"> ○ High pressure vessels ○ Valve failure <p>Noise (Lasers, chillers, are all noise sources)</p>
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<p>Administrative Controls</p>	<ul style="list-style-type: none"> • Instrument can be used independently at any time by a trained and authorized student or an employee. • Authorized personnel: Paola Russo, Ming Xiao (x. 35625). • Only authorized personnel shall operate, maintain or service the laser. • Alignment procedures shall ensure that the MPE for the eye is not exceeded. • Eye protection shall be required (NOTE: Different googles are available according to the wavelength of the laser that is in use: <ul style="list-style-type: none"> ○ Thorlabs LG9= 800 nm to be used with the femtosecond laser ○ Laser vision P5B02=OD2=532 nm for alignment of mantis ○ Laser vision T5E06= OD7= 190-565nm; OD=6 565-578nm when using TOPAS at lower wavelength ○ Laser vision T5K07=OD7+=532nm;OD3+=850-900nm;OD4+=900-950nm;OD5+=950-1000nm; OD7+=1000-1600nm;OD5+=1600-2400nm;OD5+=2900-10600nm • Black curtains in lab to protect external exposure of laser beam • Spectators are not allowed to enter the laser room. • Service personnel shall comply with control procedures. • Students need to register previously before usage • Students/ Employee should be monitored by the authorized trainer if the training is not complete or the authorized trainer believes that supervision is required during the experiments • Authorized Trainer frequently visit the lab to observe the safety operation of the instrument
<p>Engineering Controls</p>	<ul style="list-style-type: none"> • Entryway (door) interlocks (To be installed) • Warning signs • A removable beam damp is placed at the laser output during the laser warm-up stages. (To be Installed) • Warning light is used during use or start-up of the laser. • Aluminum shields to contain the laser path • The controlled areas are: <ul style="list-style-type: none"> ○ restricted to authorized personnel only ○ equipped with a device that allows for deactivation of the laser (to be installed) ○ designed to fulfill Class IV controlled area requirements ○ designed with entry safety controls (to be installed)

PPE Required

Goggles to protect the eyes from laser beam exposure (for different laser beams)

- Eye Protection → Different eyewear goggles are available at the entrance of the laser room. (See table for goggles specifications)

Brand and Model	Wavelength(s) or wavelength range (nm)	Eyewear optical density required	Total Number
Thorlabs LG9 (Femtosecond laser)	180-400	6+	4
	720-1090	5+	
	<u>750-1064</u>	<u>7+</u>	
Laser vision P5B02 (Mantis Alignment)	<u>532</u>	<u>2</u>	2
Laser vision T5E06 (For maintenance operation of femtosecond laser and when using TOPAS at lower wavelength)	190-565	7	2
	565-578	6	
Laser vision T5K07 (TOPAS at longer wavelength)	532	7+	2
	850-900	3+	
	900-950	4+	
	950-1000	5+	
	1000-1600	7+	
	1600-2400	5+	
	2900-10600	5+	

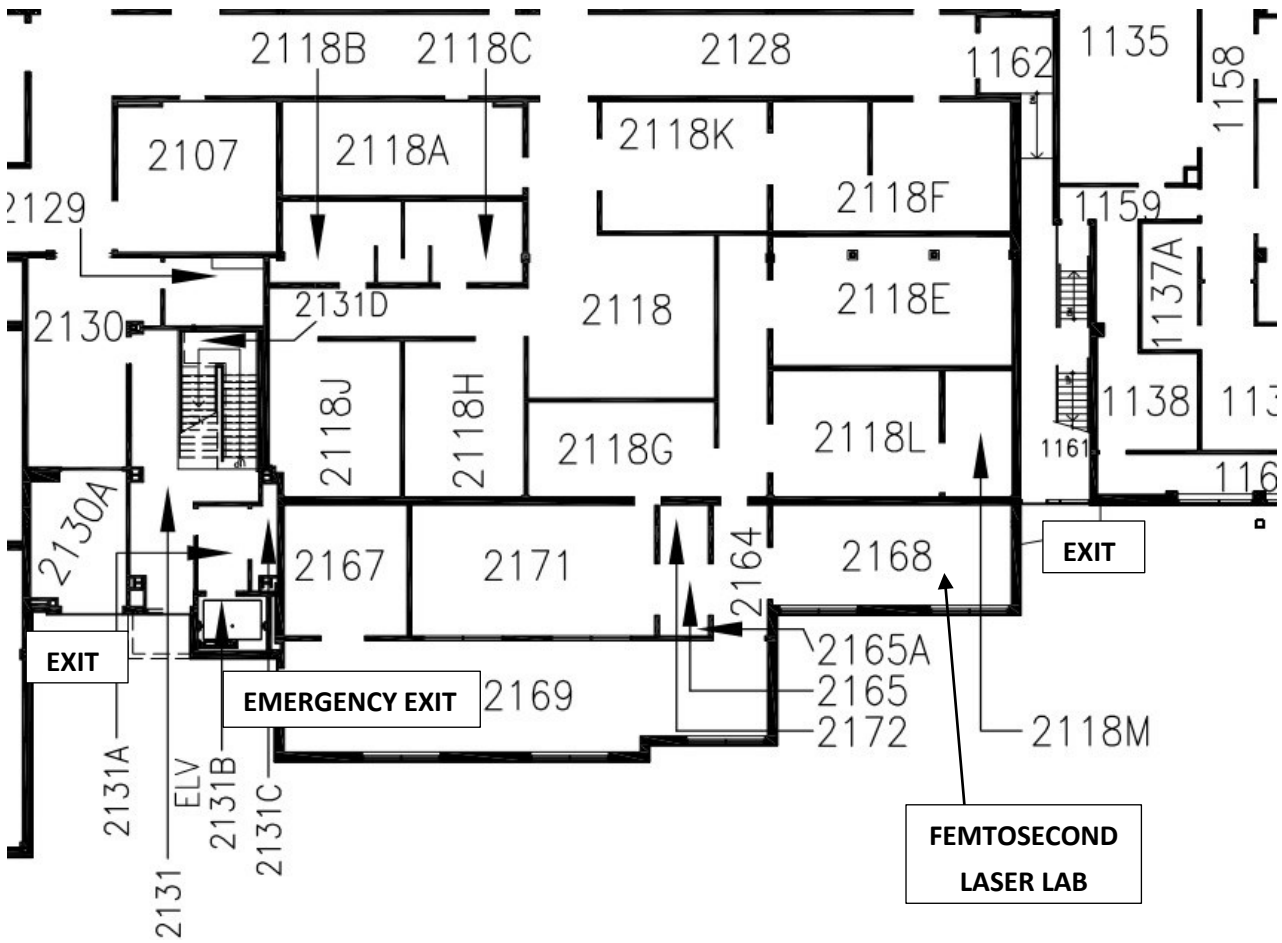
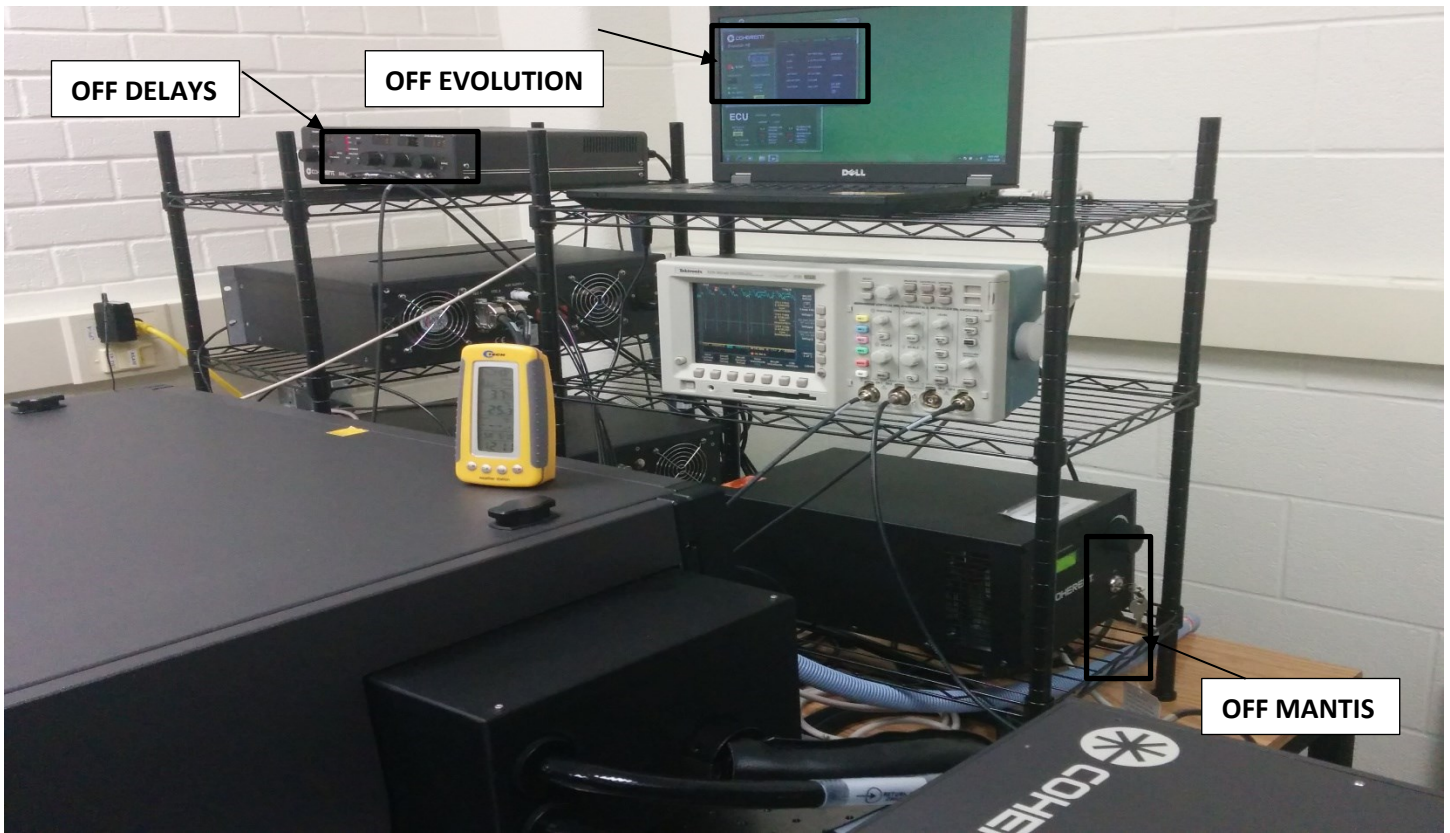
- Factors in selecting appropriate eyewear:
 - Wavelength(s) of laser output
 - Optical density requirement of eyewear filters at laser output wavelength
- Visible light transmission requirement and assessment of the effect of the eyewear on the ability to perform tasks while wearing the eyewear
- Skin Protection → Gloves are available in the laser room to wear during laser operation and materials handling.

Relevant Standards and Codes	<p>The guidance on best practice in the use of lasers is given in:</p> <ul style="list-style-type: none"> ○ ANSI Z136.1 “American National Standard for Safe Use of Lasers” ○ IEC 60825-1 “Safety of laser products – Part 1: Equipment classification and requirements”. ○ CAN/CSA E 60825-1 ○ U. S. O. S. H. A. regulations ○ U. S. CDRH Laser product performance requirements ○ Ontario Ministry of Labour follows ANSI Z136.1 ○ ANSI Z136.1 “American National Standard for Safe Use of Lasers” <ul style="list-style-type: none"> ○ Maintained and published by Laser Institute of America (www.laserinstitute.org) ○ Principle U. S. laser safety standard for laser users ○ Goal: to harmonize with international (IEC) standard ○ Changes for the 2007 version of the ANSI Z136 standard <ul style="list-style-type: none"> ○ Changes to classifications (harmonize with IEC specs.) ○ Increase duties of Laser Safety Officer
Relevant MSDS	<ul style="list-style-type: none"> ● Compressed gas cylinders – Oxygen and Argon ● Metal target: <ul style="list-style-type: none"> ○ Titanium ○ Silver ○ Nickel ○ Copper
Accident Procedure	<ul style="list-style-type: none"> ● Response/Reporting procedures ● All accidents/exposures are to be reported to supervisor as soon as possible. <p>Serious Injury/ Illness: Eye injuries, skin injuries</p> <ul style="list-style-type: none"> ● Call 911 or proceed immediately to the UW Hospital Emergency Department. <p>All Other Injuries:</p> <ul style="list-style-type: none"> ● For treatment of all other injuries, proceed to: <ul style="list-style-type: none"> ○ Department/Residence → first aid kit / station location → E3 – 2108H ○ Health Services → first aid services available → 519-888-4096, X. 84096 ○ UW Police → assists if the above services are not available → 519-888-4911, X. 22222. <p>Also see safety posters in the lab.</p>

**Emergency Shutdown
Procedure**

- **Personnel Injury:**
 - Turn off the laser system by pressing the delay off buttons, the delay keys on SDG box and turn off Amplifier from the software on the PC, shut down mantis power unit
 - Call 911 and inform the dispatcher to advise medical personnel that the accident involved lasers.
 - Contact Health Services – first aid services available → 519-888-4096 or Ext. 84096.
 - UW Police – assists if the above services are not available → 519-888-4911 or Ext. 22222.
 - Complete incident report.
- **Fire:**
 - Turn off the laser system by pressing the delay off buttons, the delay keys on SDG box and turn off Amplifier from the software on the PC, shut down mantis power unit.
 - Evacuate area as stated in your Building Emergency Plan.
 - Active wall mounted fire alarm pull station located at exits.
 - Call 911 for medical assistance (Ambulance). If using a cell/mobile call UW Police at 519-888-4911.

Report any information about fire to UW Police and Fire Department.



Pre-start Checklist

The following items that needs to be inspect before working with lasers:

- Inspect whether other laser is in operation or not by looking at the warning light. If the light is ON, in order to enter the laser room, ring the bell and wait for someone inside the laser room to open the door.
- Beware of Laser Interlocks when entering the laser room (To be installed)
- Remove any reflective material from beam path
- Enclosure of the experimental area: in order to avoid the risk of dangerous reflections the experimental area should be enclosed with proper shields.
- Humidity, Temperature values within the range that allows the operation of the laser (see Operation Manual 1)
- Correct Laser safety glasses.
- Warning light works properly
- Curtain closed.
- Door locked.
- Safety gloves.
- Work area should be clean and organized
- Emergency contact information (UW Police, HealthServices, Safety Officer)

Start-up Procedure

The following items need to be ensured before Laser operation:

- Stable modelock
- PD1 and PD2 on the SDG BOX enabled and stable (no blinking)
- Resolutions for typical problems: Allow warm up time if the problem not fixed switch OFF the laser
- What indicates all is going well : Smooth seed profile with instant modelock, good modelock seed power

Operating Procedure

Laser Switch ON Procedure

1. Safety Procedure

- Remove your foot wear outside laser room and wear laser room internal foot wear
- Lock the Front door and **switch ON** the Front door **RED Light**.
- Wear the **Thorlabs LG9** safety goggles
- Check the proper enclosure of the experimental area. In order to avoid the risk of dangerous reflections the experimental area should be enclosed with proper shields

2. Dehumidifiers operation

- Drain out the dehumidifier water
- **Humidity** on sensor should be **less than 38%** to **ON the laser**
- Three dehumidifiers available in the lab. User's decides the number of dehumidifier ON during laser operation to keep humidity less than 40%. Better always keep less number of dehumidifiers in operation at any time

3. Thermometer reading

- **Temperature** on meter should be **less than 25.5°C** to **ON the laser**. For Better operation temperature should be in between 21-22°C
- If temperature is above **25.5°C**, use temperature sensor setting on the front wall to bring it down.
- Temperature sensor setting on the wall
 - Summer - At the minimum (less than 50 indicator reading)
 - Winter - Adjust the sensor to keep on proper operating temperature

4. Amplifier chiller operation - keep chiller temperature at 23°C

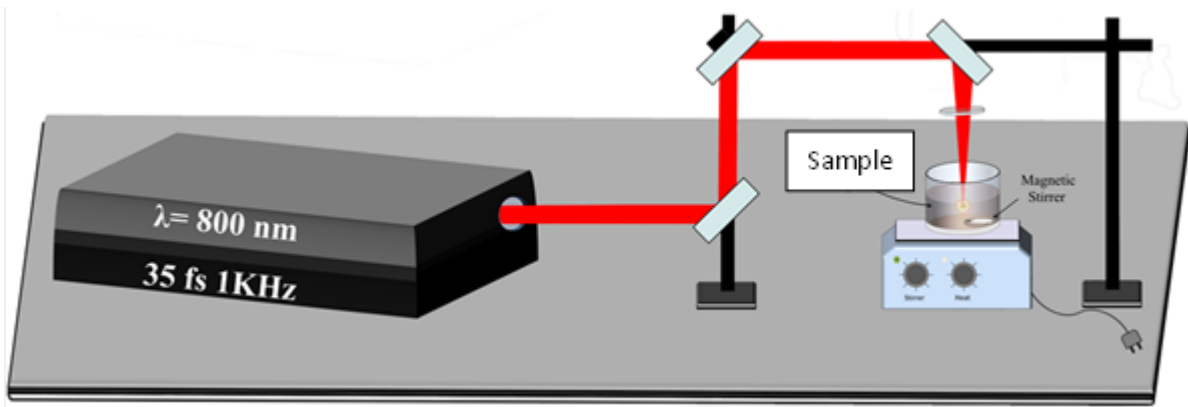
- Summer - Always ON (Whether laser operated or not).
- Winter - ON only during laser operation, otherwise OFF. Let the chiller to run 30 mins then ON the laser. (Skip this step if Chiller is already ON)

5. Check and confirm the seed laser chiller (smaller) temperature at 21°C.
6. Turning ON the Mantis Seed laser
 - Check the initial (minimum) power is 0.1 W or less
 - Gradually (very, very slowly- Don't push the black knob in) increase the power to 5.30W
 - Allow 10mins for warm up
 - Trigger the seed laser mode lock button. Press and hold for 2-3 seconds
 - PD1 and PD2 indicators turn to red confirms the mode lock is success
 - PD1 and PD2 indicators are not turn to red leave more warm up time (another 10 minutes) and Trigger the seed laser again. If still indicators are not ON switch OFF the seed laser
 - If PD1 and PD2 indicators are blinking or not stable red shows malfunctioning of system. Switch off the seed laser immediately
7. Turning ON Amplifier laser
 - ON the key switch, click the 'system' in the software and select 'internal'. Check if there is any error in the software monitor.
8. Press the ON button (green) and hold it for 3-5s until you hear 3 buzzer rings.
9. Leave the system to run 15mins.
10. After 15 minutes go to 'SDG'. Press 'Reset' first, then press from right (Delay 2) to left (Delay 1). Note that Sync will always be ON.
11. Mount the power meter and check the output power.
12. When the laser is ON in order to block the laser reaching the experimental area, place the black plate in front of the output beam window with an angle of 7° in order to avoid laser reflections back to the laser.

Experimental Setups

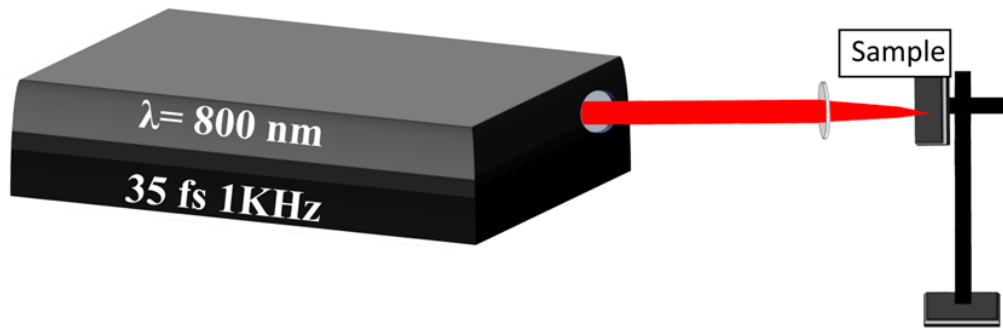
Two possible experimental setups can be employed for carrying out the experiments with the femtosecond laser.

Setup 1



- The laser ablation/irradiation is performed from the top with the use of reflective mirrors
- Extreme attention should be paid when mounting and aligning the laser beam in the center of the mirror
- Laser goggles should always be worn during the experimental setup and alignment of the mirrors.
- After the experiment has been setup, enclose the area with the shields (top and lateral) provided in order to avoid reflections of the laser beam

Setup 2



- The laser ablation/irradiation is performed in line with the laser
- Extreme attention should be paid when adjusting the sample within the laser path
- Laser goggles should always be worn during the experimental setup.
- After the experiment has been setup, enclose the area with the shields (top and lateral) provided in order to avoid reflections of the laser beam

Shutdown Procedure

The Laser can be shut down following the following procedure:

1. Check the output power, Press buttons the 'Delay' on SDG from left (Delay 1) to right (syn.). Leave the Sync ON.
2. Press the OFF button (red) and hold for 3s on the monitor.
3. Chiller is not switched OFF during summer. This step should be followed if needed. Wait for 5 - 10 mins, and then turn down the chiller.
4. Turn off the key switch on Evolution power unit after 20mins.
5. Gradually reduce the Mantis power to around 0.1W or less, and then Turn off the key.
6. Turn off the Red warning light on the front wall.
7. Keep the laser goggles on its place.

Clean-up

Clean-up procedure:

- Clean up lab and environment after experiment.
- Use logs or documentation: Operating conditions should be recorded in log book. Problems, instability, or better operating conditions all should be documented on log book.
- Where the waste goes: No chemicals, plant operation cleaner.

Lockout

Document the lockout procedure to use when maintenance or repairs are taking place. Identify and address all sources of hazardous energy. Standard service reports are implemented and filled.

Maintenance and Repair

The following procedure must be followed during maintenance and repair:

- Maintain regular log book/schedule for maintenance/repair.
- Check the laser working envelope regularly, and reposition the limit switch.

Contact with suppliers and service companies for maintenance/repair:

For Femtosecond Laser:

Company: Coherent

Person to contact: Robert Letiecq (Coherent)

Staff Service Engineer Tech support: 800-367-7890

Robert.Letiecq@coherent.com