Volume 4
Issue 1

Laser Lessons News Letter

LLNL's Gabe Guss properly using an IR viewer
Viewed image is located in top right corner
Photo Courtesy James Pryatel

This issue:

"...Ti:Sapphire lasers continue to be involved in almost all of the recently reported laser accidents. If you are using one of these lasers you need to understand that the faint spot of the laser beam is very deceptive. Like the glacier, <10% of the laser beam is visible...The seconds that you THINK you are saving may cost a lifetime of suffering. BE SAFE!"

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Introduction

We have discussed, in previous editions, much of the laser safety equipment available such as; laser protective eyewear (LPE), clothing, barriers, enclosures, etc. What about items that you use as tools in the day-to-day operation of your laser? There may be an assumption that tools used to make your job easier, by definition are safe. This is not always true as we will discuss in this issue.

Safe Use of Laser Tools

While working around a laser beam, many tools are incorporated to make your tasks easier. These are vital for making the task both efficient and safe. While they may seem inherently safe, this is not always the case. Let's look at several of these and how they should be used:

Infrared (IR) Viewer

IR viewers can be found in just about every laser lab. The purpose? To locate an IR beam's interaction with a component in your optical path. These work by taking in the laser's photons through an objective lens and changing them to electrons via a photocathode. The electrons are accelerated and strike a phosphor screen where they are imaged as intensified photons.

IR viewers work for wavelengths typically between 350-2000nm, with sensitivity quickly dissipating at about 1300nm. They are so commonplace that their use in the laser lab is second nature. Are you using them correctly?

An IR viewer should NEVER be used without LPE unless the irradiance or radiant exposure is below the maximum permissible exposure (MPE) limit. Why is this? An IR viewer is not to be considered as a safety device. The photo at the top of the page shows the correct use. Figure 1 show incorrect usage.

IR viewers can be difficult to use because it is usually a one or the other in terms of tools in hand. You may have the viewer to see the beam and then put it down and move an optic and grab it again. If you have difficulty using an IR viewer, try a camera and monitor. This minimizes moving objects around the beam path and eliminates the temptation to remove your LPE.

Figure 1. Incorrect use of IR viewer (no LPE)

Coming Events:

Save the Date

Please mark your calendars and plan to attend the 11th Department of Energy LSO Workshop.

The Workshop is for individuals with laser safety responsibility and interest in a research or academic setting who want to update and expand their knowledge. It will feature presentations on current laser applications and associated safety issues and solutions.

Anyone interested in laser safety will not want to miss this one-of-a-kind workshop! The workshop also serves as the official annual meeting o the U.S. Department of Energy Laser Safety Task Group (DOE-EFCOG).

The Workshop

The DOE-LSOW is a 2.5-day meeting and will include both invited and contributed talks.

There will be a vendor exhibit displaying state-of-the-art laser and laser safety products Wednesday, September 28th.

Tours of several Fermilab experimental facilities and associated laser systems will be conducted.

Certification Maintenance points for Workshop participation will be available. Just prior to the Workshop, on Monday, September 26th, the Board of Laser Safety will offer a CLSO/CMLSO exam.

Additional Information

More information, including abstract submission, travel and accommodations, is available on the Workshop Website. The Workshop will include a social event, which will be included in the registration fee.

For more information please contact the Workshop Chair: Matt Quinn
mquinn@fnal.gov

http://indico.fnal.gov/event/LSOW16

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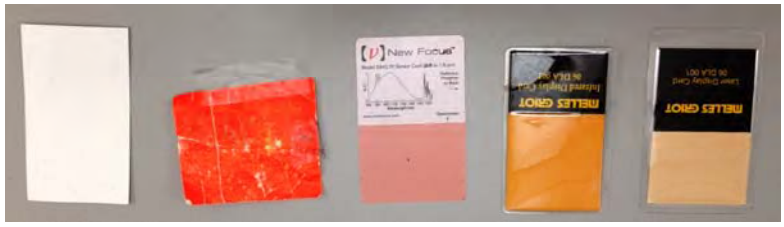


Figure 2. Assortment of viewing card options

Laser Viewing/Sensor Cards

Where an IR viewer helps you locate an invisible beam as it interacts with part of the optical train, a "Sensor Card" requires you to physically interrupt the laser beam to locate it. Because of this, these cards require a bit more thought and care in their use.

The great thing about viewing/sensor cards is that they can be purchased to view over the band of wavelengths from 250nm all the way out to 13,200nm. They work by absorbing the incoming light and reemitting it at another wavelength that you can see while wearing your LPE**!**

Because of the requirement that you interact with the laser beam, it is very important that you use these cards safely. Let's go over some basic rules:

1. Laser power/energy - This should be turned down as low as reasonable for the alignment. Sensor cards are not meant to be beam blocks for high powered beams. The plastic coating on some cards is meant to protect the sensor material, not so that the glow of the melting plastic can be used for beam location! The card should not look like target material.
2. Beam Control - Use beam blocks downstream of the beam path to prevent the unaligned beam from straying. Use two cards to locate and block the laser beam as you move along.
3. Card Handling - Always angle the cards downward so that any reflections are directed down at the table and not toward your face or others in the lab.
4. Personal Protective Equipment (PPE)- While the power/energy should be turned down prior to the alignment, even low levels of ultraviolet can be hazardous to the skin. Wear tightly woven clothes and use nitrile or other gloves. As always, WEAR YOUR LPE!

You can readily purchase an assortment of viewing/sensor cards through different vendors, but for many UV operations, one can use either fluorescent index card or even Post-it® notes. (Figure 2).

This brings up a Lesson Learned concerning the use of viewing cards and LPE. Please read and do not make the same mistake.

A laser worker was aligning a Ti:sapphire laser (780-820nm) and decided that rather than use the appropriate viewing/sensor card with required LPE, they would use a "white" index card to locate the beam.

Why would they choose to do this? Someone had mentored them with the practice that it was easier to "bare-eyeball" the faintly red laser spot on the white index card than to see it on the viewing/sensor card through LPE. Because this was an "alignment operation," stray reflections were not yet all being blocked.

The worker was struck in the eye by an unaccounted for beam and received a retinal lesion. The BIG problem here is that this is not a lone accident using this type of laser and alignment practice. This scenario continues to happen over and over again. Be sure to read the last Lesson Learned at the end of this issue. It just recently happened.

No matter how tempting it is to remove your LPE to more easier see the laser beam, you are NOT quicker than the speed of light. You will NOT escape a stay beam and you WILL be injured.

If you feel the LPE that you are using is impeding your work or making it less safe, contact your Laser Safety Officer (LSO). There are many different types of filters available from which to choose or many different ways to set your work up safely. Do not become another statistic. BE SAFE!

Fiber Optic Viewers

A fiber optic viewer is a device used to inspect the end of a fiber optic. They can be direct or indirect in their function.

A direct viewer uses the combination of a light and microscope to view the fiber end. Using this type of viewer requires an extra step of safety. Because you are basically magnifying any incoming light, it is paramount that the delivery end of the fiber be disconnected from any potentially "live" laser source.

In this situation you should always have both ends of the fiber in front of you, or in your sight, to ensure you do not view an active laser source. (Figure 3).

For direct viewers, there are filters available to block the incoming hazardous laser light, but these are wavelength dependent and they may also be missing. In situations where you do not have both ends of the fiber in front of you, the indirect viewer is the way to go.

Figure 3. Correct use of fiber optic viewer. Both ends of fiber are visible by worker

An indirect fiber viewer allows the connection of the fiber end to a camera, where the end of the fiber is imaged on a monitor. This method is safe in it does not matter if the laser is on or off. You cannot be harmed by the image viewed on the monitor.

Care must be taken when connecting and disconnecting fibers: you should not be doing this with a "live" source. You may have dangerous levels of laser radiation emitted out of the fiber end. This is particularly true when inspecting fibers where the source end is not in your control. You should follow safe beam practices and keep out of the nominal hazard zone (NHZ), where possible, or wear the appropriate LPE.

Hand Tools

These are the items that personnel working around lasers feel the safest with, but should they?

While the number one rule for laser safety is to keep items out of the beam path, you should ensure that reflective items do not get anywhere near it. This is why you remove watches, jewelry, and badges prior to doing any laser work.

While it should be common sense that you never use reflective tools to manipulate or align a laser beam, accidents continue to happen where an individual is manipulating something in the beam path or using polished or chrome plated tools and catches a beam in the eye. It should be noted that the individuals in each situation were also NOT wearing LPE (last line of protection).

Where possible, all tools that are used, kept, and stored in a laser lab should be non-reflective. This is usually accomplished by anodizing or roughening the metal.

REFRESHER– What is a diffusely reflective surface for one wavelength may be highly specular at another. A black anodized ball driver is very reflective to a 1064nm Nd:YAG laser beam. WEAR YOUR LPE AND BE SAFE!

Lessons Learned

Pre job brief saves the day

Workers were preparing to perform a new laser task which required different LPE than what was previously in use. New LPE was purchased and additional pairs were gathered from other work locations. As the new LPE was being introduced, one of the workers noticed that three pairs of the LPE did not look quite like the rest. The filter media appeared to be lighter in color and was not labeled as providing coverage for the wavelengths in use (1053nm and 527nm). The worker "paused" work and requested that the LSO be contacted for clarification.

Inspection by the LSO confirmed the worker's concern about the LPE. It had "VISIBLE ALIGNMENT" im-

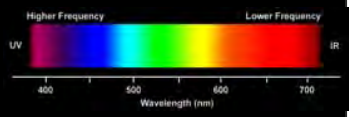
Figure 4. Wrong Eyewear for this task – "visible alignment" imprinted on left arm.

Figure 5. Proper Eyewear for this task.

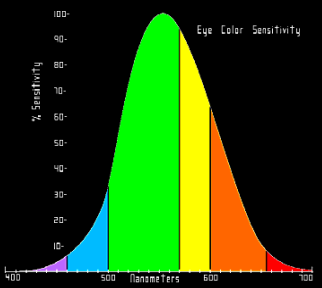
Why is the Ti:Sapphire laser in so many accidents?

(a little refresher)

The human eye has the ability to detect only a small portion of the electromagnetic spectrum. For most people, this lies between 400nm and 700nm, though some individuals have shown the ability to see out to around 800nm.



The portion of the electromagnetic spectrum that covers lasers is generally accepted to be between 100 nm and 1 mm. This leaves a very large portion that is invisible to the human eye. How does the eye perceive colors?



The highest sensitivity is at about 550 nm and trails off rapidly in a bell curve as we move farther away in each direction.

Most laser users would not question the ability of a Class 4, 1064nm "invisible" or a 532nm "visible" laser to cause an eye injury, and therefore do not hesitate in wearing laser eye protection. The hesitation comes when an individual is using "barely" visible higher powered lasers, especially during alignment operations.

The perception issue arises when we look at lasers of equivalent average power. In the picture below, the green appears to be several times brighter and thus more hazardous than the red. In actuality, they are equal in average power output.

This is a very important point to remember for those working with Ti:Sapphire lasers. Don't fall for the false sense of security of the barely visible 780-850nm laser beam.

Remember, as with an iceberg, you are only seeing a small percentage of the real hazard.

BE SAFE!

printed on the left arm of each pair and was mistakenly grabbed in the LPE hunt at other locations (Figure 4). This special LPE had never been put into service and was still in the original vendor packaging. This LPE did not provide coverage for the infrared wavelength (1053nm) that was in use. The worker used proper situational awareness and ensured that the inadequate pairs were not put into use.

In the past, one could typically identify the proper LPE to use by the color of the filter media. An infrared blocker (typically 1 μm) was green and second harmonic (527-532 nm) was an amber-colored media. There are many different dyes used to help the worker see better while wearing LPE, so color alone should not be used to determine wavelength coverage. LPE now comes in many different colors. For example, coverage for 1μm (sometimes referred to as 1ω) can now be found in green, lime green, blue, and even grey. Wearing improper LPE is like wearing no LPE at all.

With reliance on LPE as the "last line of defense," it is critical that the user verify that the LPE provide proper wavelength coverage and optical density (OD) for the wavelength in use (see the insets in Figures 4 and 5) or the LSO has verified that proper protection is provided. This is imperative in operations where more than one type of LPE is required.

LPE, like all other PPE, is an administrative control. This means it still requires a properly trained, informed, and vigilant worker with good situational awareness for it to be effective.

Pre job brief goes wrong

On October 20, 2015, a laser manager was touring the facility when he found four subcontract personnel within the electrical flash boundary of one of his industrial lasers without controls such as PPE or Lockout/Tagout (LO/TO). The subcontractor was in the process of describing planned troubleshooting work that he would need to perform the following day so that the activity could be conducted safely. To facilitate his description, the group had opened a panel on the laser machine and did not recognize that they were within the flash protection boundary of a 480 volt control board. Electrical safety practices require controls for entry into this boundary, such as LO/TO or PPE and specialized training. Work was stopped and a critique was scheduled.

Keep your head in the game. Be sure that you are aware of and mitigate all potential hazards in your area. A laser lab does not mean that there are only laser hazards present. Situational awareness is KEY!

Worker exposed to Ti:sapphire laser beam

On Thursday November 19, 2015, a worker in a DOE laser laboratory received an eye injury from a reflected, Class 4 repetitively pulsed Ti:Sapphire laser (800nm). The laser is configured to split the beam into two work areas for research experiments. During this incident, the laser output was being projected to both experimental work areas, although only one area was actively being used. The beam not being used was blocked by an optically opaque material.

In the course of conducting the active experiment, the laser worker traced the associated beam path (OD>8@800nm LPE being worn) with an infrared laser viewing card (per procedures). The worker then prepared to take measurements inside the experimental laser enclosure. In order to record two micrometer settings for the measurement, he used a small step ladder to get a better view of the micrometers inside the laser enclosure. The worker momentarily lifted his laser safety eyewear to better see the micrometer settings and noticed a flash of light in his eye. He quickly replaced the laser eyewear and located a stray laser beam, using an infrared viewer, being reflected from the inactive experiment on the opposite end of the optical table.

The beam was being reflected off the opaque piece of laser enclosure material. This material, which was not normally used as a temporary beam stop, was positioned at an inclined angle reflecting the beam toward the primary work area where the worker had been standing on the step ladder. The material had been placed there by another laser worker who had been conducting experiments several days before in the other work area. The worker identified the stray beam and blocked it with a card.

The worker did not think he had sustained any injury and continued working. Later that day, he noticed a blurry spot in the vision of his left eye. He notified his supervisor the next morning and was taken by management to the medical facility for evaluation. They did not find any abnormalities, but referred the worker to a local ophthalmologist for further evaluation. Over a period of 3 days (11/21-11/23) the ophthalmologist identified a small spot of inflammation near the fovea on the retina in his left eye.

The ophthalmologist stated that this spot would most likely heal on its own and that the blurry spot on the worker's vision would go away. A follow-up visit was scheduled and the worker was released back to work without restrictions. An investigation of the incident was performed on 11/23. Based on the investigation and the presence of a spot of inflammation on the worker's retina, it was concluded that the worker was exposed in excess of the associated MPE limit.

These Ti:Sapphire lasers continue to be involved in almost all of the recently reported laser accidents. If you are using one of these lasers, you need to understand that the faint spot of the laser beam is very deceptive. Like the glacier, only <10% of the laser beam is visible. Do NOT remove your eyewear while in the NHZ of an operating laser. As discussed in this issue, there are many tools available to perform your work safely. The seconds that you THINK you are saving may cost a lifetime of suffering.

BE SAFE!