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Fermilab Class 3B/4 Laser Alignment and Maintenance Procedure

System Description: MicroBooNE UV laser calibration system alignment procedure

FNAL Laser ID Number: 293,308

Location: LArTF

AUTHORIZATION

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Revision History

Author	Description of Change	Revision Date
Thomas Strauss	First draft	11/25/2014
Thomas Strauss	Separate into Alignment and Operation, update by experience from the lessons learned in Dec'14	04/17/2015
Michele Weber, Sam Zeller	Major revision	1/26/2018

Laser Hazards

Laser Radiation Hazard

Under normal operations the laser is operated in a closed box and the laser light is contained to the boxes and the MicroBooNE cryostat, which are optically isolated at the single photon level for PMT operation. Opening of the box is only possible with mechanical tools. Therefore, under normal operation NO LASER HAZARDS are involved.

For special alignment, the laser needs to operate with the laser box opened. In this situation laser beam of **Class 4** pose a hazard. The following table summarizes the laser light wavelength and pulse power. Two such laser boxes with a laser system each are present at LArTF.

Class 4 Lasers: Are hazardous under direct, specular, and diffuse reflections. They can also be skin hazards and may pose a fire hazard.

Laser	Wavelength	ANSI Class	Average Output Power	Peak Power	Repetition Rate	Pulse Width	Energy/ pulse	OD
(2) Continuum Surelite I-10	**266nm**	4	-	-	10Hz	4-6ns	60 mJ	4.8
	355						65	2.3
	532						200	6.3
	1064						450	5.7

Cryogen Use

No cryogenic use intended for laser operation.

Chemicals & Compressed Gasses

No chemicals or compressed gas use intended.

Electrical Hazards

The lasers use commercial power supplies. Under normal operating conditions, these power supplies do not pose a hazard. No work may be done on power supplies without additional procedures that comply with Fermilab ES&H Manual (FESHM) requirements for electrical work.

Changing of harmonic generation crystals must be done according to Continuum "Operation and Maintenance Manual for Surelite Lasers."

No components may be worked on while the system is energized.

Other Special Equipment

In normal operation mode, the system is fully enclosed and sealed light tight, so no special equipment is needed.

During alignment, the system will not be fully enclosed, as the laser box will be opened to allow access to the beam for alignment and cross-checks. Metric tools and a set of lock keys are required to open the boxes.

A low power green alignment laser of Class 2 or 3a is used, which poses no particular hazard.

System Configuration

There are two independent (but identical) laser systems consisting of:

1. A laser rack, with power supplies, cooling, UPS, laser controls and laser data acquisition
2. A connection corrugated pipe with laser power and trigger cables and cooling water for the laser head
3. An enclosing laser box with the laser head and optical systems (frequency doubler, filters, collimator, beam dumps, extraction mirror)
4. A connection pipe to the cryostat, attached to the laser box and the laser feedthrough on the cryostat.

There are two configurations with specific Hazard Zones: one for normal laser operation, and one for maintenance and alignment.

Nominal Hazard Zone for normal operation

In normal operation, there are no accessible zones with relevant laser hazards.

The Nominal Hazard Zone is restricted to the non-accessible areas in the enclosed boxes, connections, and the MicroBooNE cryostat.

The laser boxes cannot be opened without tools and configuration control locks are placed on the box covers. There is no access (non-destructive) to the connections. Access to the MicroBooNE cryostat is not possible, as it is a sealed pressure vessel filled with liquid argon. It is optically sealed for single photon PMT operation.

Nominal Hazard Zone for maintenance and alignment

Periodically, the UV lasers boxes will be opened for inspection and the laser alignment checked. For these operations with access to the laser boxes, the Hazard Zone is extended to the LArTF building.

Engineering Controls

X Beam Enclosures

☐Protective Housing Interlocks

X Beam Stop or Attenuator

X Key Controls

☐Activation Warning System

X Room Interlocks

☐Ventilation

☐Other

Engineering Controls Description

Beam Enclosure:

The UV laser is completely enclosed by a light tight housing. Access is only possible by means of mechanical tools and the opening of hardware (locks and screws). Four padlocks secure the laser box.

Prior to the operation of the UV laser system, the light-tightness of the system will be checked using the internal PMT system of the MicroBooNE experiment. The PMTs are highly light sensitive detectors that will allow identification of any light leaks before laser operation. The PMT rate is checked before any laser operation.

The MicroBooNE cryostat is filled with ultra-pure liquid Argon. The cryogenic system is automatized and runs 24/7. Internal sensors control the pressure in the tank (slightly over atmosphere, to avoid the seeping in of contaminations from air). In case of a leak, the whole system will send out an automated alarm that will be signaled in the MicroBooNE slow controls system (monitored 24/7 by MicroBooNE shifters) and distributed to on-call cryogenics experts. If any such event occurs, data-taking will be stopped, including any laser operation.

Key Controls:

There are two sets of keys: keys (A) to access the configuration control locks on the laser boxes and keys (B) to the laser power supplies to start operation.

Keys (A) ensure that the laser boxes are closed for normal operation, and therefore the Nominal Hazard Zone limited to non-accessible space. Keys A are usually kept by the ELO when access is not needed.

Keys (B) are used as a supplemental control for the normal laser operation. These keys are stored and locked in a special cabinet in the ROC-W control room when the laser is not used. They are used to activate the laser power supply either for each single laser calibration run or for a period of laser runs.

Powering Interlock

In order to protect the light-sensitive PMT system in the MicroBooNE cryostat, the laser system is interlocked with the high voltage of the PMT system. The laser power supply is enabled if the PMT high voltage is turned off.

Room Interlocks:

During data taking of the experiment, access to the MicroBooNE LArTF building will be possible only on the loading dock and the DAQ room areas. Access to the platform where the readout crates and DAQ crates are situated, as well as access to the lower level with the cryogenic system is restricted by keyed access doors with access permission granted by the MicroBooNE Run Coordinator in compliance with MicroBooNE rules. This interlock system is used to comply with the ODH regulations of the LArTF building.

Access to the LArTF building is only possible with keycard and access rights granted by the Neutrino Division Experiment Liaison Officer (ELO) assigned to LArTF.

During special laser alignment periods, access to the LArTF building is restricted by placing one person outside the building to prevent unauthorized personnel from entering the building and informing those on the inside if someone wishes to enter, such that alignment work can be stopped. The laser will only be operated in single shoot mode, so in case of emergency, no potential hazards arise. Warning signs will be posted at the entrances to the building to make people aware of the dangers. The MicroBooNE collaboration and the LArTF access list will be informed that the building is off-limits during the procedure.

Administrative Controls

(SOP for Special Alignment Mode)

The alignment mode is a special setup required after the first installation, the first filling of the detector with argon, and during periodic maintenance of the laser box hardware. As this is a special intervention, specific procedures are described here.

In addition to alignment, the maintenance can include the check of vendor specifications of the installed wavelength doubler packages to get the IR laser of 1064nm to an UV laser at 233nm. The laser tuning and operation ratings for the laser can also be checked and tuned for the best energy output and stability. Cleaning of the laser boxes and optical components from dust is a further maintenance goal.

Only MicroBooNE laser system experts, with laser training and eye exam (aka operators) as per Lab safety policy, and who have been authorized by Laser Owner signature on the SOP Signature and Laser System–Specific Training Checklist pages below are allowed to work in this mode.

If possible, laser maintenance and alignment operations is to occur after regular work hours so less traffic goes by the building and no random walk-in occurs.

Procedure to change from normal operation to alignment and maintenance mode:

1. Obtain approval by the Run Coordinator for changing operation mode.
2. Inform the MicroBooNE shifter and Neutrino Division Experiment Liaison Officer (ELO) that a laser alignment is about to occur.
3. Inform the MicroBooNE collaboration and LArTF access list of the test and restricted LArTF access via email.
4. Post one person outside LArTF to warn approaching personnel of the ongoing test
5. Place clearly visible signs at the entrances to the building warning that laser alignment is in progress and that no one is permitted inside LArTF
6. Walk-through of the building to check that no unintended personnel are in the LArTF building. The walk-through must include the entire building (all levels) and the DAQ room annex.
7. Optional: Check that the DAQ system is set to UV Laser mode
8. Check that the PMT HV is turned off
9. Check that the UV laser system is off and set to manual local single shot mode
10. Open the gratings according to the fall protection rules
11. Use PPE as described in the respective section
12. Open the UV laser boxes (tools and keys) and connections as required

Operation and maintenance guidelines

- Operate the UV laser in single shot mode only
- Remove all watches, rings, badges, and other reflective items and jewelry from the wrists, neck, head and chest before any alignment activity begins. Use non-reflective tools whenever possible, such as screwdrivers with a matte finish.
- Follow all manufacturer instructions
- Only trained personnel authorized by the laser owner or designee may perform the alignment.
- Control the beam path with Thermal/Laser paper
- Only equipment and materials necessary to perform alignment should be present in the immediate work area. Remove all unnecessary tools, electronics, and combustible materials to minimize the possibility of stray reflections and non-beam accidents.
- If possible, avoid using beam paths that are at sitting or standing eye level.
- Where feasible, use low power (class 2 or 3A) visible lasers to simulate the path of high power or invisible lasers.
- Whenever possible, reduce all high-power laser beams to the minimum possible power.
- Where feasible, terminate laser beams and specular reflections on diffuse reflecting beam blocks.
- Locate any specular reflections of the beam and block them as close to the source as possible, before moving to the next optical component or section.
- Place beam blocks behind optics (e.g. mirrors) to terminate beams that might miss optics during the alignment.
- Use beam shutters (on laser) to block high power beams any time they are not actually needed. Be sure to terminate the beam at the end of its useful path.
- Do not point the laser at mirror-like surfaces.
- Use phosphor cards, UV/IR viewers, video cameras or other display devices to locate invisible beams.
- Be sure all beams and reflections are properly terminated prior to high power operation.
- The dedicated Interlocks and warning for the open head operation provided by the vendor will be used if applicable

Procedure to change alignment and maintenance mode to normal operation

1. After the alignment is complete, the laser owner or a trained designee should perform a safety review of the laser and beam area.
2. Turn off the UV laser.
3. Close the UV laser boxes and flanges, re-secure the padlocks, and re-seal the opening.
4. Check mechanical integrity of the system.
5. Control the openings with thermal/Laser paper for potential light leaks
6. Request that the Neutrino Division ELO verify and document in the MicroBooNE e-log that the laser box lid and locks are in place after the alignment has concluded.
7. Remove the warning signs at the entrances to the LArTF building.
8. Check the light tightness by cross-checking the PMT event rate after turning the PMT high voltage on and document in the MicroBooNE e-log.

Service SOP

Service will require that lasers are: sent back to the manufacturer, serviced in a Class 4 laser lab, or performed by trained personnel following the procedures for beam alignment detailed above. Service contractors are required to follow FESHM requirements.

Personal Protective Equipment

Skin Protection:

Skin protection including gloves and a face shield is required for UV beams in accordance with Fermilab ES&H rules.

Eye Protection:

All laser eyewear needs to be approved by the LSO.

Frame: GPT LGM (Spectacle) 31-5011
CE specifications (EN207)
180-315 DL7 + IRL4
315-532 DIR L5
800-1080 DIR L5

Filter: GPT Glendale Filter 111 - Argon, NdGa:YAG

Application: Argon, NdGa:YAG
Color/VLT: 14% - Brown

OD >9 @ 190-520nm
OD >7 @ 520-532nm
OD >3 @ 710-750nm
OD >5 @ 750-800nm
OD >6 @ 800-850nm
OD >7 @ 850-1080nm
OD >7 @ 10600nm
OD >5 @ 9,000-11100nm

SOP Signatures

The signatures of the users listed in the following table indicate that they have read and understood the contents of this SOP and agree to adhere to the requirements and guidelines contained within. Only persons who have signed below and have been authorized by the Owner may operate lasers covered by this SOP. Additional authorization may be required to perform items listed in the SOP. Other required training and authorization are detailed in the Laser System-Specific Training Checklist.

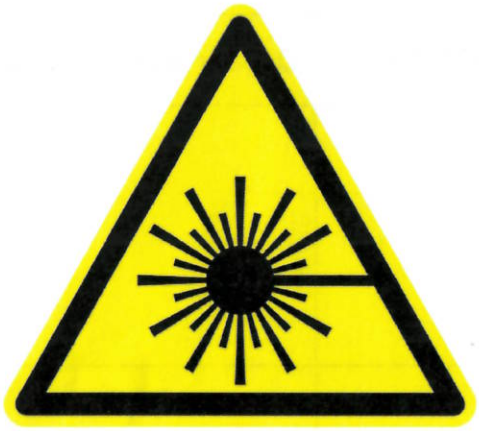
User	Signature	Date	Owner Signature

Laser System–Specific Training Checklist

Laser User:	
Laser Owner:	Michele Weber, Igor Kresslo
Laser System:	Continuum Surelite I-10

Topic	User Signature/Date	Owner Signature/Date
General Laser Safety • Hazards in the LArTF • Good practice in the LArTF • Laser Training class • Operation of the MicroBooNE laser system		
Laser Alignment Procedures • Sweeping/securing LArTF • Accessing Laser • Eyewear • Alignment • In-depth knowledge of the Bernese UV laser system • Securing laser box. • Fall protection training • ODH requirement • Laser training and eye exam		

WARNING



Non-Interlocked Class 4 Laser Service Access Panel

Avoid direct eye exposure to direct and scattered laser radiation.

Laser eye and skin protection required when open.

OD	6	@	1064	nm
	6.3	@	532	nm
	2.3	@	355	nm
	4.8	@	266	nm

Do not open without the permission of one of the following:

Carrie McGivern x6337
Cindy Joe x3886
Michele Weber x4759 (webermi@fnal.gov)

Laser Safety Officer:_Matt Quinn_x5175