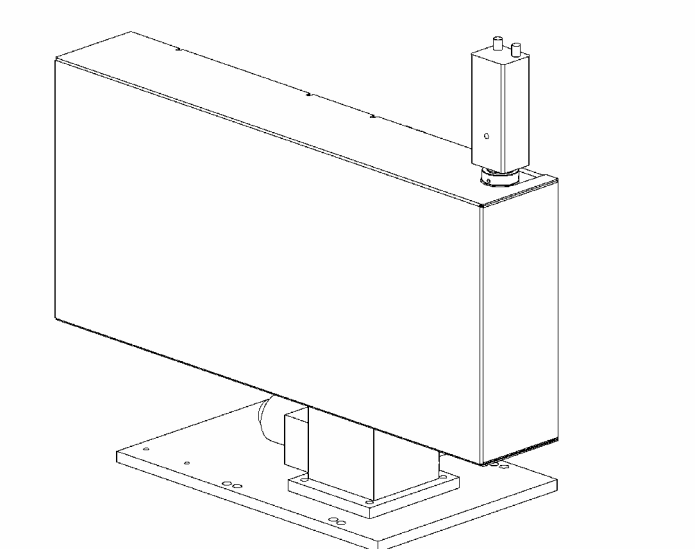
MIR Series

Laser Fusing and Heating Systems

Operator's Manual

(MIR10, MIR10-50 and MIR10-IR Probe)



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Preface

This is the User Manual for the New Wave Research MIR Series Laser Fusing & Heating System.

The **Getting Started** chapter briefly describes the system and installation procedures.

The **Operating Basics** chapter covers basic principles of operation. The software overview and tutorial examples will assist in developing an understanding of how the system operates.

The **System Maintenance** chapter provides user maintenance procedures.

The **Troubleshooting** chapter provides simple troubleshooting guidelines.

The MIR Series -Laser Fusing & Heating System is a complete, integrated system for locating**,** observing, fusing and heating solid samples. The standard system includes:

- A TEM00 CO2 laser capable of delivering up to 80 Watts, depending on the model of system, at a wavelength of 10.6micron to the sample site.
- A high magnification video system.
- High precision stages providing resolution of better than 1 micron.
- A totally integrated platform allowing complete computer control of all functions

Safety Summary

Review the following safety precautions to avoid injury and prevent damage to the Laser Ablation System or any products connected to it. To avoid potential hazards, use the system only as specified.

WARNING: The MIR Series -Laser Fusing & Heating System contains subsystems that present dangerous voltage, current and radiation hazards. Only qualified personnel should perform service procedures.

Optical Safety

The MIR Series -Laser Fusing & Heating System is based on a CO2 laser that generates high power infrared radiation that can pose serious risks to eye safety. Infrared radiation is invisible to the eye so the hazard is not immediately obvious, but the radiation can be focused onto the cornea. For this reason it is very important to wear safety glasses and be aware of any possible reflections.

WARNING: The CO2 laser in the MIR Series -Laser Fusing & Heating System is a Class IV high power laser whose beam is, by definition, a safety and fire hazard. Take all necessary precautions to prevent accidental exposure to both direct and reflected beams. DIFFUSE, AS WELL AS SPECULAR BEAM REFLECTIONS, CAN CAUSE SEVERE EYE AND SKIN DAMAGE.

WARNING: BECAUSE THE 10.6 micron OUTPUT BEAM OF A CO2 LASER IS INVISIBLE, IT IS EXTREMELY DANGEROUS. Infrared radiation passes easily through the cornea and focuses on the retina of the eye where it can cause instantaneous permanent damage including blindness. AVOID EYE AND SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

CAUTION: USE OF CONTROLS, ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE.

Follow the instructions contained in this manual for proper and safe servicing of your laser. Wear protective eyewear; selection depends on the energy and wavelength of the laser beam as well as operating conditions. Consult ANSI, ACGIH or OSHA standards for guidance. At all times during maintenance or service of your laser, avoid exposure to the laser or collateral radiation exceeding the accessible emission limits listed in "Performance Standards for Laser Products," 21 CFR 1040 10 (d).

Laser Safety

Laser light poses safety hazards that are not associated with conventional light sources. Special precautions must be observed when maintaining or servicing the MIR Series -Laser Fusing & Heating System. The safe use of lasers requires that all personnel working in the laser area are aware of the dangers involved.

Laser beams are intense enough to burn skin, clothing or paint. They can ignite volatile substances such as alcohol or other solvents. The beam may also cause damage if reflected from some other surface. For this reason, it is important to observe the following precautions for Class IV.

- Avoid eye contact with the output beam, even diffuse reflections are particularly hazardous when the protective cover is removed.
- Treat back reflections from any optic surface as you would the main laser beam. Even though the energy of such reflections is only a fraction of that contained in the main beam, it is sufficient to cause serious bodily harm, especially to the eye.
- Use protective eye-wear at all times. Selection depends on the wavelength and the intensity of the radiation, conditions of use and visual function required.
- Operate the laser at the lowest possible beam intensity.
- Avoid blocking the output beam or its reflection with any part of the body.
- Establish a controlled access area during maintenance and service. Limit access to those trained in the principles of laser safety.
- Maintain a high ambient light level in the laser operation area to constrict the pupil of the eye, reducing the possibility of injury.
- Post warning signs prominently near the laser operation area.
- Provide enclosures or barriers for beam paths whenever possible.
- To prevent unnecessary reflections and scattering, set up energy absorbing targets to capture the laser beam. If laser service is required, contact New Wave Research at Tel (406) 586-3159 or Fax (406) 586-3220.

Electrical Safety

WARNING: The laser head and power supply contain electrical circuits operating at lethal voltage and current levels.

It is important that all personnel using the laser observe all safety precautions outlined in this manual.

There are no user serviceable electrical components on the electrical side of the Laser Power Supply. New Wave Research must carry out Service procedures on power supply electronics.

Safety Features

The following features are built into the MIR Series -Laser Fusing & Heating System and conform to government regulations to provide safe laser operation.

Laser Covers

The CO2 laser beam is enclosed in a protective housing which prevents access to stray radiation. Do not remove the cover, except to perform maintenance procedures by trained personnel.

Interlocks

The MIR Series -Laser Fusing & Heating System has a series of interlocks to prevent accidental exposure to dangerous levels of electricity or radiation. In addition, there are interlocks designed to interrupt laser operation if the laser is damaged. The interrupts are:

- CO2 laser cover opened.
- Remote interlock.
- Laser head temperature too high.
- Cooling water flow too low.

Laser Light Emissions

When the laser system is assembled on the 3-axis stage assembly, the laser beam exits as shown in figure 1.

WARNING: The CO2 laser in the MIR Series -Laser Fusing & Heating System is a Class IV high power laser whose beam is, by definition, a safety and fire hazard. Take all necessary precautions to prevent accidental exposure to both direct and reflected beams. DIFFUSE, AS WELL AS SPECULAR BEAM REFLECTIONS, CAN CAUSE SEVERE EYE AND SKIN DAMAGE.

Government Regulations

New Wave Research suggests that laser users purchase a copy of the 'American National Standard for the Safe Use of Lasers' (ANSI Z136.1-1993). This publication provides recommendations for the safe use of lasers and laser systems. The publication is available from:

Laser Institute of America
12424 Research Parkway, Suite 125
Orlando, FL 32826
(407) 380-1553

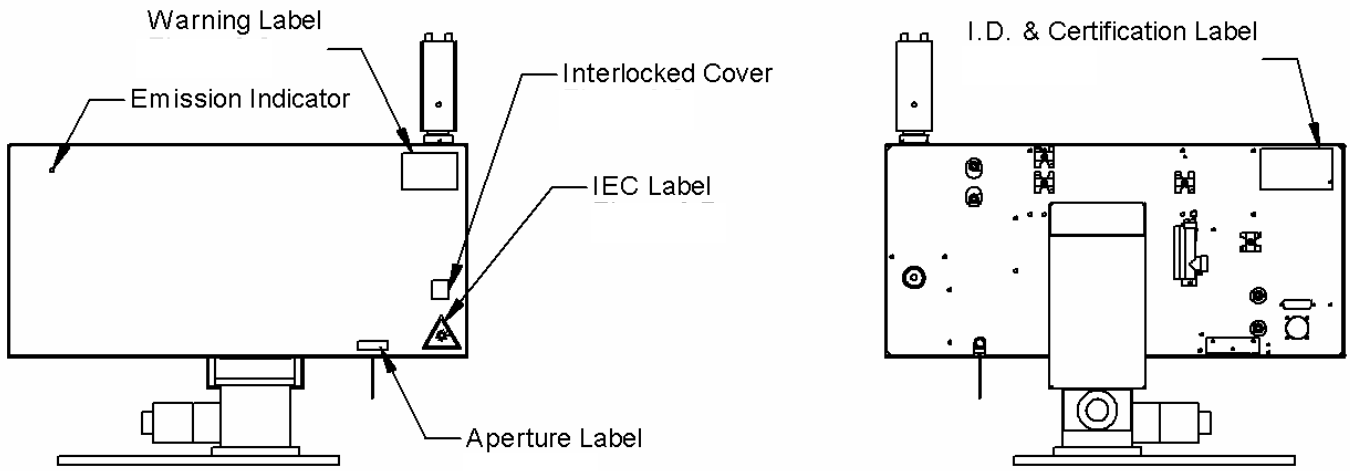
Laser Classification

The governmental standards and regulations specify the laser must be classified according to the output power or energy, and laser wavelength. The MIR Series -Laser Fusing & Heating System is a Class IV laser system. The laser is classified as Class IV based on 21 CFR, subchapter J, part II, section 1040-10(d) and Class IV based on EN 60825-1, clause 9 of the European Community Standards.

Location of Safety Labels

The MIR Series -Laser Fusing & Heating System consists of two subassemblies, the base unit and the laser unit. Laser Safety label locations are shown below.

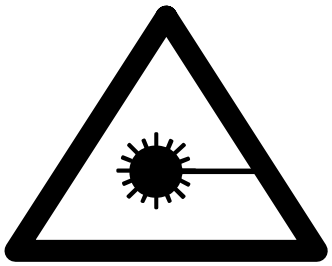
Figure 1-a



Safety Label Locations – Laser Unit

Safety Label Locations – Power Supply

Certification & Identification Label



IEC Label

Warning Label

VISIBLE AND INVISIBLE LASER RADIATION IS EMITTED FROM THIS APERTURE

AVOID EXPOSURE

Aperture Label

DANGER

VISIBLE AND INVISIBLE LASER RADIATION WHEN OPEN AND INTERLOCK DEFEATED. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION

Interlocked Cover

Safety Labels

Chapter 1 – Getting Started

System Overview

The MIR Series -Laser Fusing & Heating System is a compact laser system providing a versatile method of sampling and analyzing solids for noble gas and isotope ratio mass spectrometry.

The MIR Series -Laser Fusing & Heating System is a complete, integrated system providing all aspects of laser control, beam delivery, sample observation and sample manipulation under full computer control.

Laser Module

The MIR Series -Laser Fusing & Heating System incorporates a specially designed TEM00 CO2 laser. The Laser Module also contains the video system, including a high-resolution CCD camera, 6x computer-controlled zoom, high magnification objective, laser power meter, and a coolant safety flow switch.

Base Module

The Base Module contains the X-Y-Z stages with counterbalance mechanism.

Laser Electronics Box

The Laser Electronics Box contains the power required to operate the laser head, laser control electronics and X-Y-Z stepper motor controllers.

Start Up

Preparation

The MIR Series -Laser Fusing & Heating System installation procedure is relatively simple, but does require some preparation. Prior to unpacking the system and installation, evaluate the physical arrangement of the laboratory to choose a suitable location. The following sections discuss space, electrical and laser safety requirements. Proceed with the installation once a suitable location has been selected and prepared.

WARNING: Do not power-up the Laser Ablation System before reading and understanding the operating and safety procedures. Use of controls, adjustments, or performing procedures other than those specified may result in hazardous laser radiation exposure and personal injury, laser system damage, and void the warranty.

Space Requirements

The Laser Ablation Base Module and Laser Module require 14 x 26 inches (36 x 66 centimeters) of countertop space (figure 1). In addition, space must be

made for the computer, monitor, keyboard, and mouse if the system is not integrated with the mass spectrometer. The Laser Power Supply usually sits on the countertop and occupies a 9.2 x 10.5 x 7.1 inch (24 x 27 x 18 centimeter) footprint (figure 2).

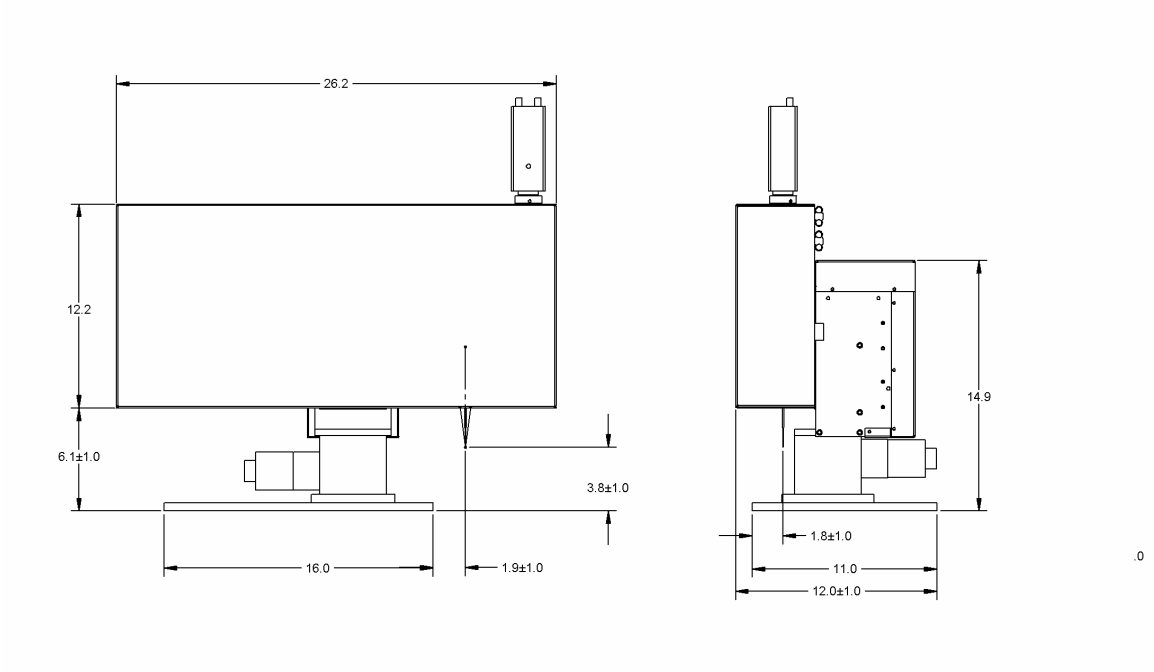


Figure 2

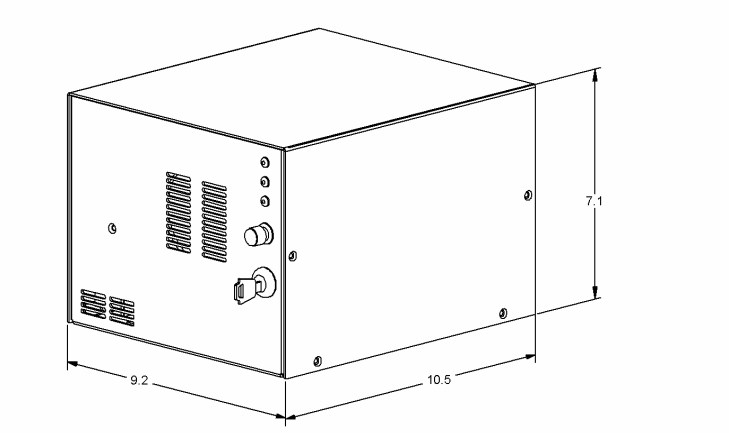


Figure 3

Electrical Requirements

The Laser Ablation System is shipped configured as either a 110 VAC, 10 A, 50/60 Hz or a 220 VAC, 5A, 50/60 HZ system. In either case, the system should be located within 6 feet (2 meters) of four power outlets for the: Base Module, Laser Power Supply, computer, and computer monitor.

DANGER – HIGH VOLTAGE: Both the Laser Module and the Laser Power Supply contain electrical circuits operating at lethal voltage and current levels. Always disconnect and wait at least one minute to allow capacitors to bleed down before servicing any part of the laser system.

A power cord set that meets the requirements of the country in which the system was purchased is provided with every system. If the system is used in another country, a power cord set that meets the requirements of that country must be used. User replacement fuses provide electrical overload protection.

WARNING: This system is designed for connection to a grounded outlet. The grounded type plug is an important part of the safety design. To avoid the risk of electrical shock or damage to the system, do not disable or remove this feature.

Laser Safety Requirements

As a Class IV laser product, the MIR Series -Laser Fusing & Heating System emits hazardous laser radiation during normal operation. To protect personnel the following guidelines are recommended:

- Establish a controlled access area for laser operation where entry is controlled and limited to individuals trained in laser safety practices.
- The area should be well lighted, and enclosed by solid walls (no windows) and ceilings.
- "Danger – Laser in Operation" warning signs should be prominently posted at all approaches outside of the laser operation area.
- Use ANSI/OSHA approved CO2 laser protective eyewear at all times.

DANGER – INVISIBLE LASER RADIATION: The MIR Series -Laser Fusing & Heating System uses a Class IV CO2 Laser. The output beam is, by definition, a safety and fire hazard. Precautions must be taken during the use and maintenance to prevent accidental exposure to direct or reflected radiation from the laser beam.

System Installation

The MIR Series -Laser Fusing & Heating System is shipped in 2 wooden crates. The optional computer is shipped in 2 cardboard boxes. Upon receipt of packages verify that there is no visible damage to the packaging. If damage has occurred, document the damage and call an engineer @ New Wave Research for instructions on how to proceed.

The MIR Series -Laser Fusing & Heating System features a counterbalance mechanism to provide a balanced load on the Z-axis stage for smoother movement of the laser head throughout the full range of travel.

Unpacking

Packaging consists of a long, narrow wooden crate and a crate that is closer to square in shape. The long crate contains the laser head and the square crate contains the motorized stage assembly, light source, electronics module, and accessory boxes. Remove the covers from the shipping crates (a motorized drill with a Phillips driver bit is recommended for removing the screws securing the shipping cover). The screws that need to be removed have arrows pointing to them or have been circled with a black marker. Save all packaging in case the system should ever need to be returned for repair.

Figure 3 shows the laser head in a crate and figure 4 shows the motorized stage assembly, light source, electronic module, and accessory box in a crate. These photos and this document should be referred to should the system ever need to be returned to the manufacturer.

Figure 4 Laser Head in Crate

Figure 5 Motorized Stage Assembly in Crate

All items should be handled with care. The motorized stage assembly weighs approximately 40 lbs and should be handled so as not to damage the stages. The

laser head should be handled with care to prevent misaligning the laser and video system.

Clear an area approximately 14" x 26" in size. See figure 5 for a system layout. Note the location of the laser system focal point relative to the system base plate to plan where the sample chamber should be located. The focal point location is shown in the nominal position and can move +/- 1" in all directions. Also note the size of the electronics box and the light source. The electronics box has 6' cabling connecting it to the laser. The electronics box should be place where the Kill Switch can be easily accessed and the indicator lights can be seen. The light source needs to be located within 2' of the laser system and will need to be accessed to adjust illumination intensities.

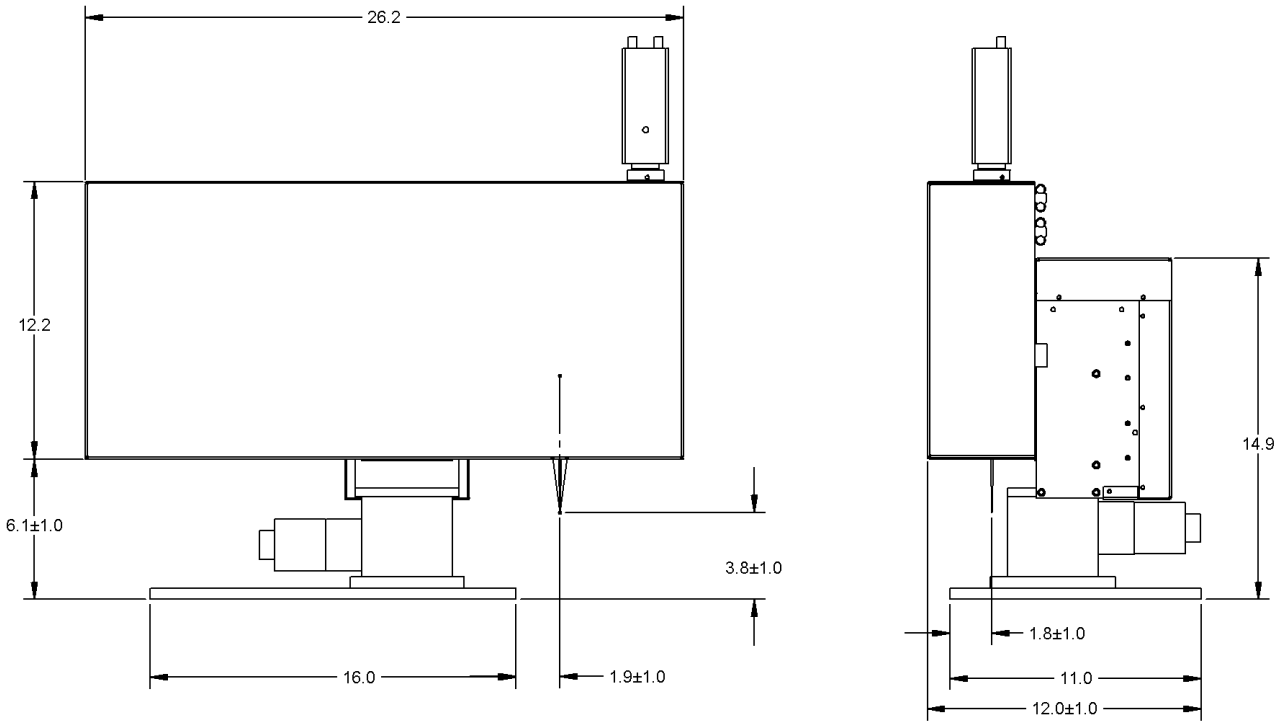
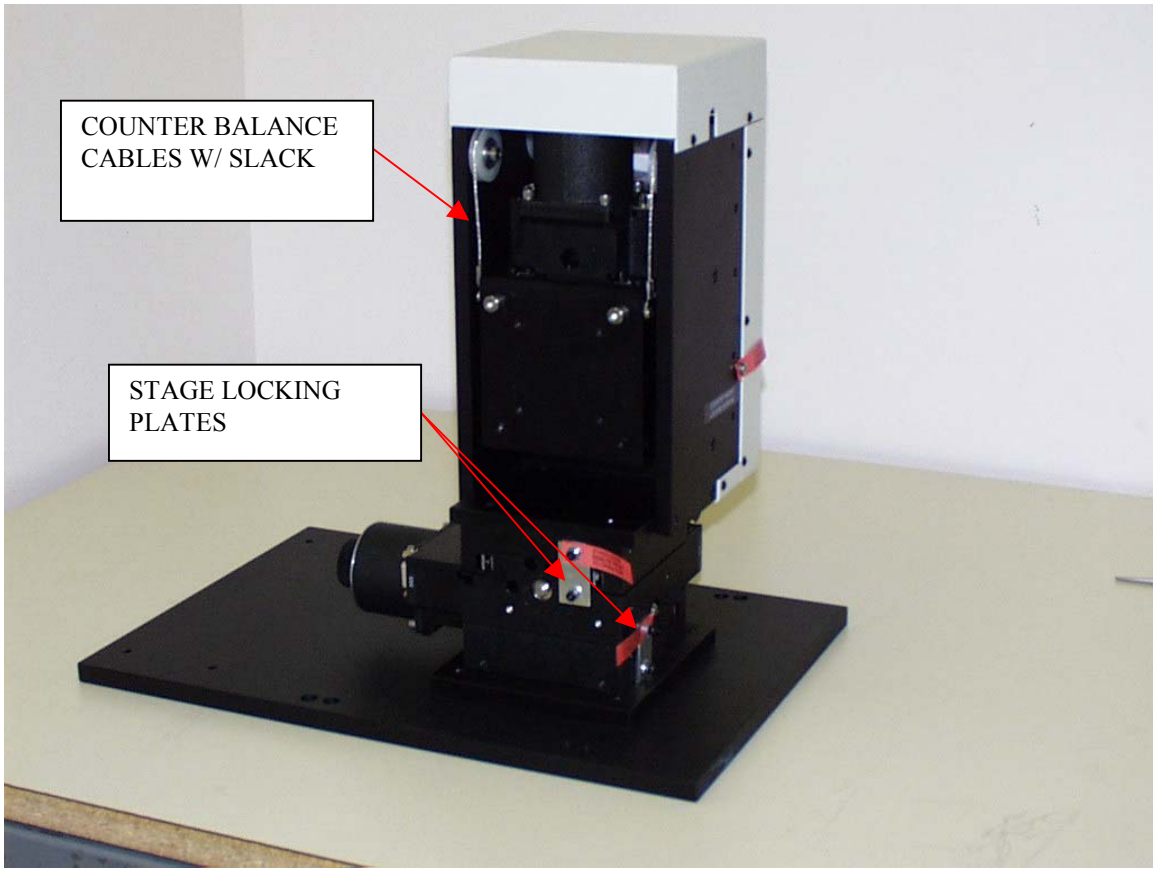


Figure 6 System Layout

Carefully remove the electronic module, light source, and accessory boxes from the shipping crate and set them aside. Next remove the motorized stage assembly (see figure 6). Two people may be needed to lift the assembly because of its weight of approximately 40 lbs. Set this assembly on the stable, flat mounting surface where the laser ablation system will be operating. The weight assembly should be secured to the mounting surface with either ¼-20 screws or 6mm screws.



BASE ASSEMBLY

There are 2 small plates on the X-Y stages securing them for transportation. These small locking plates must be removed at this time. Failure to remove these plates prior to operating stages can cause severe damage to the motorized stage assembly. The Z-axis of the stage assembly is shipped without these locking plates.

Remove the upper counterweight cover revealing the Z-stage motor and counterbalance cables. The cables have slack in them to protect the Z-stage during shipping (see figure 7). Verify that the counterbalance cables are still on the pulleys. Loosen the counterweight shipping screws (qty 2 - see figure 8) 1 revolution each. Manually rotate the Z-axis motor until the cables are taut and the counterweight shipping screws rotate freely. Remove the counterweight shipping screws saving them in case the system ever needs to be shipped at a later date. Replace the upper counterweight cover.

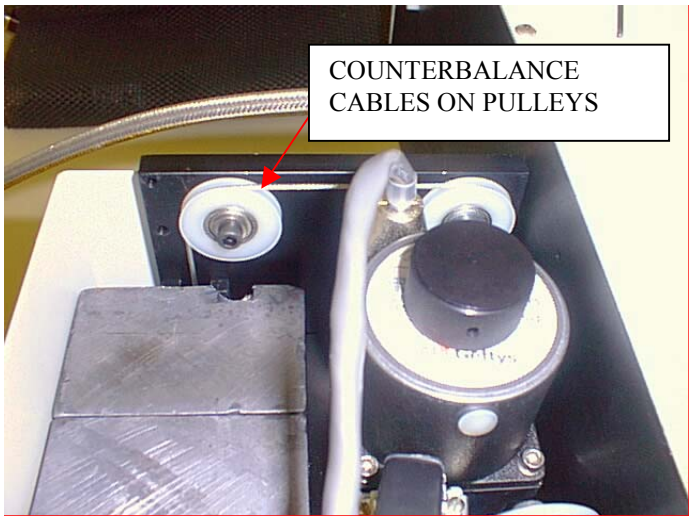


Figure 7 Counterbalance cables

Figure 8 Counterbalance shipping screws

The stage assembly is now ready to have the laser head mounted on it. The front of the z-axis stage has 4 screws in it (see figure 9). The upper 2 screws are shoulder screws. Check these screws to make sure that they remained tightened during shipping. Do not remove these screws. The lower 2 screws need to be removed prior to mounting the laser head. These screws will be reinstalled to secure the laser head to the z-axis plate.

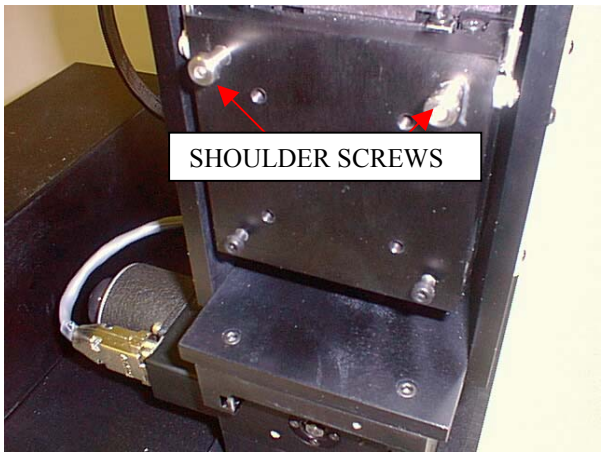


Figure 9 Laser Head Mounting Screws

LASER ASSEMBLY

The back of the laser head has 4 holes for mounting. The 2 tapered keyholes are for the shoulder screws and the lower 2 holes are for the 10-32 screws (see figure 10).

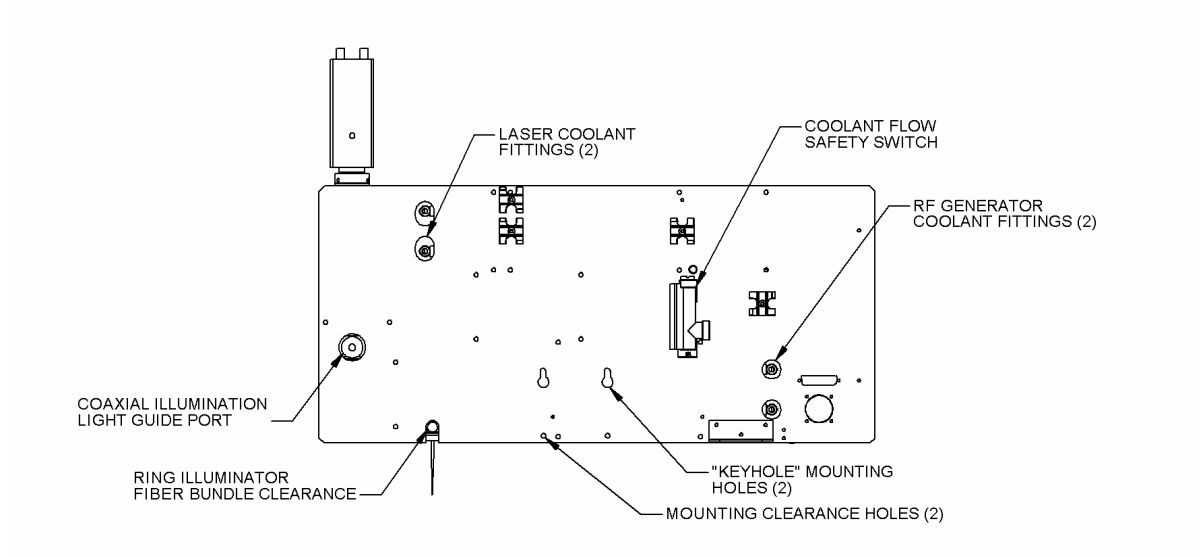


Figure 10 Laser Head Mounting Holes

Remove the cover from the laser head and mount the laser head to the Z-axis stage. Secure with the 10-32 screws. Use the 5/32" T-handle ball driver included in the accessories kit to tighten the mounting screws.

Remove the large yellow dust cap from the top of the video zoom and mount the camera/video adapter assembly. To ease realignment the piece of tape on the video adapter should be aligned with the piece on the zoom (see figure 11). The

video adapter is secured to the zoom with 3 set screws (5/64" hex wrench). Connect the camera power connector and the S-video cable to the camera.

Figure 11 Video Adapter/Zoom Assembly

Remove the threaded shipping cover from the output tube of the beam delivery and mount fiber optic ring illuminator. The fiber bundle must exit through the slot at the back of the plate directly behind the output of the system.

Connect the cables to the laser head and stages from the electronics box. All necessary cables for operating the system are included in the accessories kit. Be careful not to misconnect the cables to the stages. Doing so can cause severe damage to the motorized stages.

Connect the coolant lines to the laser head. Fittings for ¼" ID tubing and 12' of PVC tubing have been shipped with the laser. Connect these to a coolant source providing at least 1gal/min of flow. Make sure that the inlet and outlets are properly connected or water will not flow past the flow switch causing maximum coolant pump pressures in the lines. Note: this situation could possibly cause the coolant lines to burst. A check of the flow switch is strongly recommended prior to operating the laser and monthly thereafter. Checking the flow switch can be done when the software is operating by simply shutting off the cooler. When this happens an interlock warning status will appear on the screen and the software will not allow the laser to fire.

The computer is not auto-voltage switching. Be sure to provide power to each component that matches the labeled power entry connector voltage.

The connections to the computer should be as shown in figure 12. Be sure to plug the computer monitor into the PCI frame grabber card and not into the on board video card. The S-video cable should also be plugged into the PCI frame grabber card. The RS-232 serial interface cable should be plugged into the serial port of the computer (not to the PCI frame grabber card) and to the electronics box.

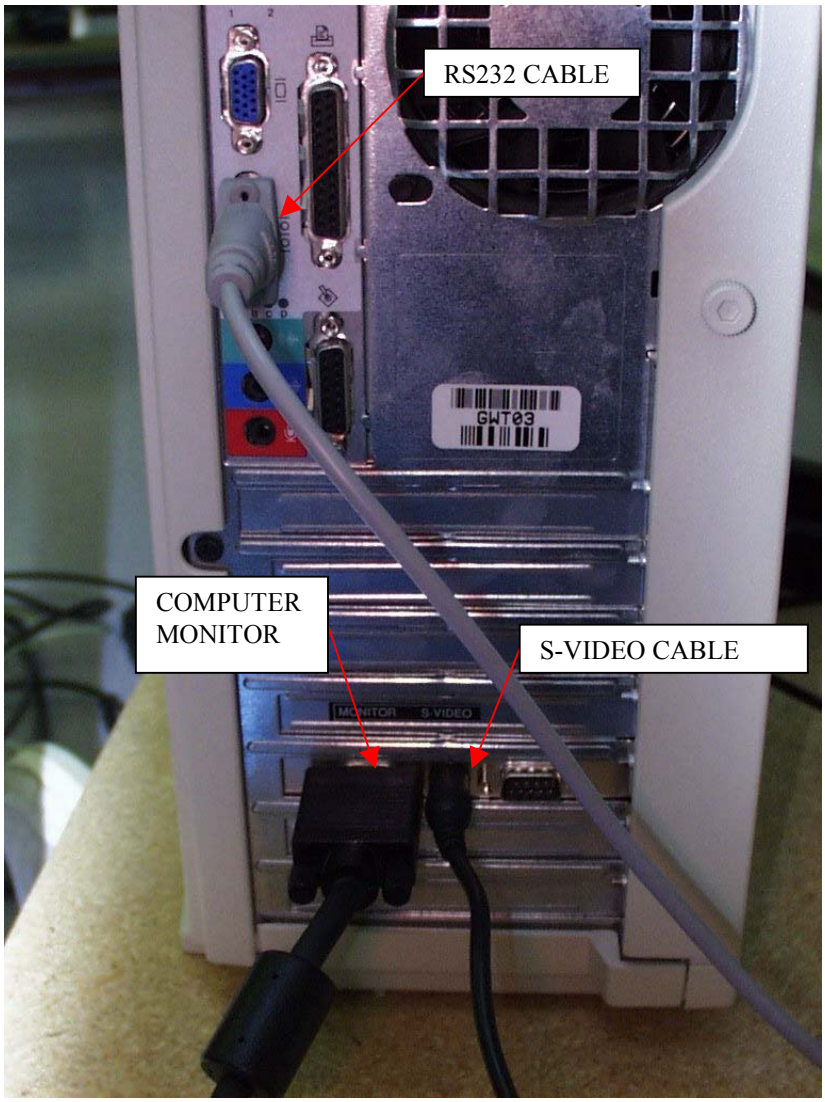


Figure 12 Computer Cable Connections

Finish setting up the computer by connecting the keyboard and the mouse.

Prior to starting the system check to make sure that the laser head can travel +/- 1" in all directions without hitting any surrounding items which might be on the same table as the ablations system.

The laser system should now be ready to start. The electronics box power switch must be turned on prior to starting the ablation software. If the software is started first it will not find the controllers for the ablation system.

If the MIR Series -Laser Fusing & Heating System is shipped or removed from storage during cold weather, allow the system 4 to 8 hours to attain room temperature before opening and exposing to warm, humid air.

WARNING: If condensation forms on or inside the MIR Series -Laser Fusing & Heating System, allow it to dry thoroughly before connecting to the AC power source and operating. Failure to do so may cause injury or equipment damage.

WARNING: Secure all connectors. Operating the Laser Ablation System with cables loose or disconnected may cause equipment damage.

Cooling System

- The MIR Series -Laser Fusing & Heating System must be liquid cooled. The software will not allow the laser to fire without coolant flow. The laser requires >1lpm of flow @ <70psi. An average of 1-3 lpm is recommended. Excessive pressure can cause coolant lines to burst or coolant connections to come apart. Tap water can be used as coolant for the laser system. The temperature should be kept within a range of 15-30º C. The cooling system that is utilized must maintain 1-3 lpm and 15-30º C. You can utilize a heat exchanger, chiller or tap water that will maintain these parameters.
- The coolant switch functionality should be checked monthly. Turn the system on and try firing the laser without the cooler turned on. The laser should not fire. If it does contact Service @ New Wave Research for a new flow switch.

External Connections

AC Power Connections

Verify that the available power is the correct voltage and install the power cords for the Laser Power Supply and Base Unit.

WARNING: To avoid the risk of electrical shock or damage to the Laser Ablation System, verify that the correct voltage is provided.

System Verification

Power On

Turn the power switch on the Electronics Box (switch located in back), the computer, the monitor and the key-switch on the power supply to the ON position.

Starting the Software

Use the Start button on the Windows Task Bar to locate the New Wave Research folder. Choose the MEO Laser Ablation icon to run the software.

As the software loads, a system self-test and subsystem resource verification will be performed. The results of the subsystem resource verification are reported in the Startup screen. Any errors detected during the self-tests will be reported in special message windows.

The Startup screen provides the following status information concerning the results of the resource verification:

- Laser Controller Present.
- X-axis Stage Controller Present.
- Y-axis Stage Controller Present.
- Z-axis Stage Controller Present.

If any of these controllers are not located, contact a New Wave Research representative as the system may require maintenance.

Once the self-tests are complete, the Startup screen disappears and the main program window appears.

Establishing Coolant Flow

The Laser Power Supply is interlocked to shut down the laser due to inadequate coolant flow. Upon startup a Coolant Flow interlock warning may appear until the cooler has enough time to establish the proper flow rate.

Testing the X-Y Stages

Press the right mouse button over the **Position** button and select **Home Stages** to verify the stages properly home. Move the stages back to the center position to verify the jog and step buttons are working properly.

Testing the Z Axis

Using the focus toolbar, move the Z-axis up and down until the object is in focus to verify smooth operation of the Z-axis.

Testing the Video System

Zoom out and locate any feature in the center of the screen - zoom in, focus and center the feature. Zoom out and verify the feature stays focussed and centered on the screen.

NOTE: A solid blue screen indicates that the video card is not receiving a camera signal. If this occurs, verify that the S-video cable is connected between the Electronics Box and the computer.

Locate a feature relative to the horizontal bar of the cross hairs. Jog the x-axis from left to right watching the feature relative to the horizontal bar on the cross hairs. If the feature moves up or down relative to the horizontal bar then the camera needs to be rotated relative to the stages.

Chapter 2 – Operating Basics

Getting Started with the Software

This section provides a quick overview of the MIR Series -Laser Fusing & Heating System software and instructions to perform basic procedures. Detailed help may be obtained by pressing the F1 key or by selecting the Help->Contents menu.

Software Overview

The main program window controls the sample stages, light sources, gas valves and video system. Use the mouse to change a value, increment a number, push a button or make a selection. Many of the controls also have *properties* which may be accessed by pressing the *right* mouse button over the control.

Controlling the Laser

The laser control block, located in the upper right of the screen, provides complete control of the laser parameters, including the ability to manually fire the laser.

The **ON/OFF** button puts the laser into an idle mode where pressing the FIRE button will not fire the laser.
The **MODE** button allows selection between four modes of operation: Continuous, CW, Burst and Single Shot.
The **REP RATE** button selects the laser repetition rate.
The **PULSE WIDTH** button allows changing the duration of the laser pulse.
The **SPOT SIZE** button controls the laser beam expander to produce the desired spot size. A number of predefined beam expander settings are provided. See Establishing Optimal Beam Characteristics to calibrate the materials being ablated and set laser power level. Manual control and calibration of the beam expander is controlled using the right mouse button.
The **LASER POWER** button selects the laser power level. The slider bar next to the Laser Power button allows for rapid changing of the laser power.
Pressing the **FIRE** button fires the laser. A small animated laser icon shows when the laser is active. Pressing the right mouse button while on the Fire button allows opening and closing of the laser shutter. The power output of the laser system is displayed in Watts.

Navigating

There are scroll bars located at the bottom and right of the live video display. These scroll bars function much like the scroll bars used in word processing or

other application, and can be used to move the stages to view different areas of the sample. The scroll bars have two sets of buttons:
STEP buttons for moving the stages a specified distance;
JOG buttons for moving the stages at a specified speed for as long as the button is pressed. Press the right mouse button to edit the stage properties which include step size and jog speed.
Press the **POSITION** button (located to the left of the stage position display) to move to a previously saved position or save the current position.

Sample Maps

Sample Maps allows viewing of an area larger than the screen. Sample Maps are an array of screen shots which are placed together to form a large view of the sample. Features of interest in the sample map can be moved to the center of the screen by selecting them in the sample map with the mouse.

Stage Calibration

Stages must be calibrated before running scan patterns. To calibrate, send the stages to home position. The stage coordinates will be zeroed and the system ready for use. A special homing routine insures that the home positions are accurately located.

Defining Experiments

Scans are individual patterns such as a line or spot that define a specific area on the sample. An experiment is a set of one or more scans that run as a continuous series, are saved and recalled in a file.

Scan patterns are placed by selecting a scan pattern type from the toolbar (located above the video window), pressing and dragging the mouse across the video window. Once placed, scans appear in a list to the left of the video window for editing, deletion or selection.

To edit the scan properties *before* placing a scan, press the scan button on the toolbar. These properties are used as the default properties for all new scans.

To edit the properties *after* placing a scan, select the scan from the scan list and pick properties.

Saving Images and Experiments

Save/recall experiments and video images from the File menu. Saving an experiment includes all properties of the scan.

Chapter 3 – Troubleshooting

Interface Problems

Computer fails to find System

- Check serial cable installation between the computer and Electronics Box.
- Check the Electronics Box power.

Safety Interlock Problems

Remote Interlock Failure

- Disconnect wiring to Remote Interlock Connector on back of Electronics Box and replace with shorting cap provided.

Coolant Flow Interlock Failure

- Check the coolant flow (pump turned on).
- Turn pump off and remove bottom fitting from flow switch. Manually push the flow sensing plunger and check the interlock status.

Cover Interlock Failure

- Check the cover (secured).
- Open the cover to verify the switches still work and the wiring is OK.

Laser Problems

Laser to Video Misaligned

- Use the turning mirror to realign the laser.

Laser Doesn't Fire

- Check the cabling between the Electronics Box and Laser Head.
- Check the laser coolant flow.