CETAC
LSX-213 Laser Ablation System

Operator's Manual

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REVISIONS

CETAC Technologies strives to provide the scientific community with an unparalleled combination of effective technology and continuing value. Modular upgrades for existing instruments will continue to be a prime consideration as designs progress.

CETAC Technologies reserves the right to revise this document and/or improve products described herein at any time without notice or obligation.

TRADEMARK ACKNOWLEDGEMENTS

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1 Introduction

Overview

The CETAC LSX-213 Laser Ablation System is the next generation UV laser ablation system from CETAC Technologies. The LSX-213 system features a high-energy 213nm laser, with improved viewing optics and an improved version of the operating software, DigiLaz™ III.

The LSX-213 system is a self-contained solid sampling accessory that can be installed on any ICP-OES or ICP-MS.

Figure 1-1 The LSX-213 Laser Ablation System.

The LSX-213 Laser Ablation System generates particulate aerosols from solid material by an extremely rapid interaction between a high energy UV laser pulse and the sample surface. This process is referred to as ablation. Adjusting laser energy, spot size and pulse frequency using the DigiLaz III software optimizes signal intensity and stability.

Ablated material is swept into the ICP-MS or ICP-OES by the helium carrier gas. Many types of samples can be analyzed using laser ablation sample introduction including glasses, coatings, refractory materials, powders, ceramics, geological samples, process materials and polymers.

Some of the features of the LSX-213 Laser Ablation System include:

- Ultraviolet laser, >4 mJ at 213 nm with a pulse width of < 6 nsec
- Low ppb detection limits possible with ICP-MS
- Ultra-stable laser system, < 1% RMS
- Q-switched control of laser frequency, 1-20 Hz
- User-friendly DigiLaz III software with on screen sample viewing and host ICP computer integration
- Microstepping X-Y-Z translation stage with 0.25 µm step size
- Additional sampling methods for additional flexibility
- Included thin-section or petrographic slide holder (grooved to accept standard size slides)
- New illumination system provides extraordinary lighting clarity in both transmitted and reflected sample viewing
- Fast auto-ramping sample navigation (no abrupt starts or stops while moving)
- Sample image and image map save, retrieval, and export

The LSX-213 system provides a means of rapid, direct analysis of solid samples without dissolution and with minimal sample preparation. Ablation may be performed on samples of electrically conductive or non-conductive materials.

Principles of Operation

Laser Ablation Processes

Laser ablation ICP-MS, as an analytical technique in itself, has been described in books and review articles in detail; it is an ablation process in which a laser is used as the primary energy source. When a laser beam of sufficient power density strikes a solid material, it generates particle aerosols into the gas phase. This ablation process is caused by the interaction of laser photons with the solid material.

Typically, a solid sample is placed inside an enclosed chamber (the sample cell) and a laser beam is focused on the surface of the sample. When the laser is fired, a cloud of particles is produced. These particles are removed from the sample cell by the helium carrier gas, and are swept into the ICP plasma for atomization and ionization and subsequent analysis.

System Overview

The LSX-213 Laser Ablation System is a stand-alone unit supplied with a cart for easy portability. The system includes the laser system and an external power supply/chiller.

The LSX-213 is shipped fully operational and is easily installed.

Hardware interlocks and other safety features are included in the laser and power supply modules. These interlocks monitor the status of the entire ablation system and will ensure that all safety contacts are closed and the hookups are correct before the laser can be operated. The laser will immediately switch off should any interlock be opened or in any other way defeated.

Laser Ablation System

The LSX-213 employs a specially designed Nd:YAG laser, frequency quintupled to the ultraviolet wavelength of 213 nm. These features provide a uniform energy profile ("flat-top profile) across all spot sizes ranging 10 µm to 200 µm and, consequently, a flat-bottomed crater on the sample. The aperture system uses a motor driven ceramic wheel with six spot size choices that are accessed within the laser software.

The laser can be operated at a high repetition rate of 20 Hz for increased sampling efficiency, and thus provide better ICP-MS sensitivity and importantly, the pulse repetition rate is controlled via the laser Q-switch. The pulse repetition rate varies from 1–20 Hz.

The LSX-213 sampling cell is mounted on an X-Y-Z translation stage, with a step size of 0.25 □**m.**The translation stage provides X-Y positioning control for laser targeting on the sample and is under computer control. The Z-axis of the translation stage is used to focus the laser via the CCD camera viewing system. The sample image is viewed directly in the DigiLaz III software. The interface achieves superior optical viewing of the digital image created by the sample (see Figure 1-2).

Since air is unavoidably admitted into the sampling cell when changing samples, removing the air from the carrier gas flow path prior to switching back to the ICP-MS is required to prevent plasma collapse. To purge the sample cell and prevent plasma collapse, the LSX-213 is equipped with 3-way electrically actuated valves to direct the carrier gas flow to either the ICP-MS, to a purge position or to a bypass position.

The CCD camera microscope system provides a means of visual identification of the sample areas of interest and also for laser focusing. A digital crosshair is an integral part of the digital image and can be adjusted depending on the visual aspect of the samples. This crosshair provides a targeting mechanism for the sample positioning at the point of laser impact.

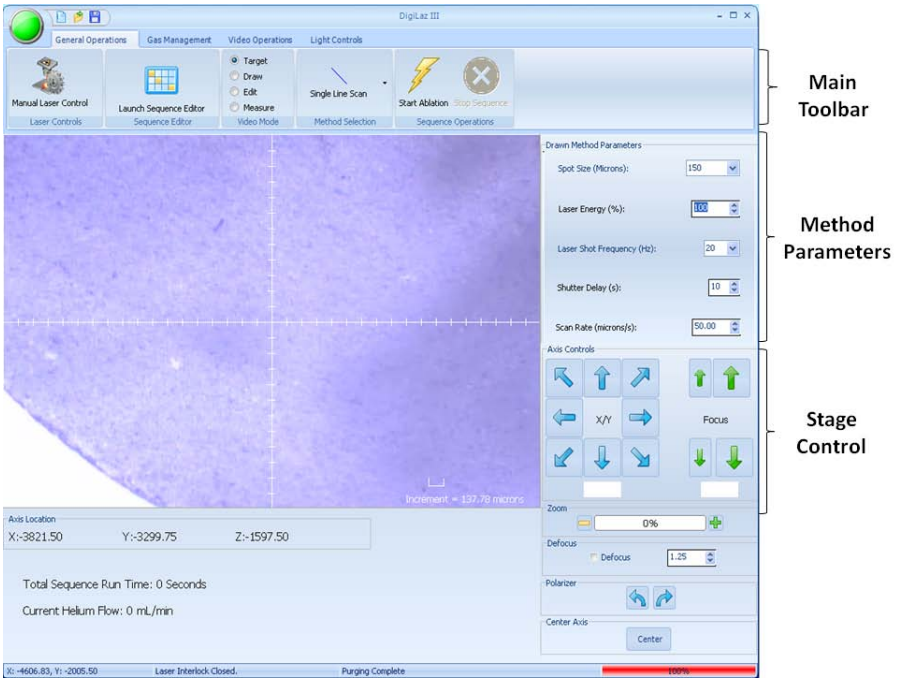


Figure 1-2 Sample Viewing Within the DigiLaz III software

Laser Head and Optics

The laser head is located in the upper chamber of the laser module. It is a compact, rigid and stable-structured unit with a folded resonator geometry. The opto-mechanical design of the Compact Folded Resonator (CFR) has evolved over many generations of iterative refinements based on usage and experience.

All of the optical elements are kept in precise relative alignment through precision mounting techniques onto a single, stable optical table which is both thermally and mechanically isolated from the rest of the system to minimize any environmental influence on the laser or optics. The laser system used for the LSX-213 system uses a liquid chiller which maintains a constant temperature on the optical plate whether the unit is running at 100% or idle. This results in unsurpassed laser stability and reliability.

Laser Characteristics

- Frequency quintupled, Q-switched Nd:YAG laser, 213 nm
- Spot size range: 10–200 µm (apertured)
- >4mJ/pulse laser energy, 1% RSD, 1% RMS, computer controlled
- Laser output energy is adjustable from 0–100%
- Flat-top laser beam energy profile
- Laser pulse width: < 6 nsec
- Q-switch controlled laser frequency selection 1–20 Hz

Viewing Optics and Video System

- High intensity reflected and/or transmitted light illumination
- Computer controlled focusing
- 5X, 40 mm focal length UV achromatic lens
- Computer controlled polarizers for transmitted and reflected light
- Thin-section holder for petrographic slides and other transparent samples
- Real-time image acquisition at 1152 x 864 pixel resolution

Sampling System

- Standard cell is 52 mm diameter by 52 mm high
- Multiple cell types available to suit nearly any sample type
- Quick release sample stage for easy sample exchange
- Motorized X-Y-Z translation stage, 52 mm travel axis
- 0.25 µm step size, 0.05 µm resolution
- 3-stage motor drivers with manual override, auto-ramping up to 2 cm/sec
- Adaptable volume, Teflon® and Viton™ construction
- Automated valve system switches between cell purge, bypass, and online modes
- Ablation cell with removable quartz window for easy cleaning or replacement

Computer Hardware and Software

- The DigiLaz™ III software controls all laser functions and runs on the same computer which controls the ICP for maximum ease of use
- Compatible with the Microsoft Windows XP, Windows 2000, Vista, and Windows 7 operating systems
- Communication via serial port or USB
- On-screen display of safety interlocks and laser status including laser firing, door open, coolant temperature and flow interlocks
- Universal communication protocol for synchronization of ICP-MS and laser system using contact closure
- Built-in laser ablation methods including multi-spot analysis, line scans and raster, segmented line scanning, area scan and raster and advanced depth profiling
- Method/sequence saving, export and loading with sample image capture and export. Method file management and text (*.txt) file management access
- Spot size and feature measurement functions
- Single shot or automated repetition (burst or continuous mode)
- Computer adjustable spot size using aperture focusing of the laser beam

- Automated video zoom and sample motion control

System Characteristics

- Dimensions: Laser Module 69 x 46 x 51 cm
- Weight: approximately 57 kg (125 pounds)
- Power supply: 20 x 30 x 37 cm
- Power requirement: 100-250 VAC +/- 10%
- Class 1 enclosure with safety interlocks
- Independent programmable laser power supply module
- Closed loop water cooling system with integrated DI cartridge

Options

- GeoPro™ data handling software for geological analysis and transient data collection
- Custom designed sampling cells, oversize cell, document cell, core cell, small sample cell. Inquire about custom designs

Laser and High Voltage Safety Features

- The LSX-213 system has built in safety interlocks to disable the laser in the event the cover is opened or the front door is opened during operation. Another interlock on the laser power supply deactivates the laser if its cover is opened during operation.
- The laser power supply is controlled by a key switch and the key can be removed only when the switch is in the OFF position to prevent unintended operation.

Laser Ablation System Components

The LSX-213 Laser Ablation System is composed of the following components.

- **LSX-213 Module.** The laser module contains the laser itself, all optics, apertures, lighing etc. The sample cell on the translation stage is accessible through the door and is pulled forward for easy access to the sample cell.
- **Power Supply.** The LSX-213 power supply and integrated laser head cooling unit contains all electronics for interfacing with the LSX-213 system and safety interlocks for the laser head.
- **Host Computer.** The control computer, whether integrated into the ICP computer or a stand alone laser specific computer, executes the LSX-213 DigiLaz III software. The user-programmable software issues commands that control LSX-213 functions, such as X-Y-Z sample positioning, laser firing mode, laser power, CCD camera digital zoom, sample cell illumination level, and sample cell purge/ICP argon flow control. System safety and laser firing status are also monitored and displayed.
- **Host Computer Monitor.** The real-time sample image and software controls are displayed on the monitor.

NOTE:

Please contact CETAC Technologies (800-369-2822, 402-733-2829) if you need additional accessories not listed, need added features to integrate the LSX-213 Laser Ablation system into your analytical system, or have unique requirements. Research and development of new features and accessories for the LSX-213 Laser Ablation System are inspired by customer requests, and responding to such requests is a continuing activity of CETAC Technologies.

Who Should Use This Product—Operator Qualifications

The laser ablation system, along with this book, is intended for use analytical chemists and lab technicians. To use this product safely and effectively, at least a beginning level of knowledge and experience about laser safety, electrical/ electronic equipment operation and maintenance, personal computers and ICP-MS or ICP-OES are required.

WARNING

CHEMICAL INJURY HAZARD
The autosampler is intended for use only by qualified operators who have been trained in safe laboratory practices. Make sure you know the hazards associated with all of the chemicals you are using, and take the appropriate precautions. Exposure to laboratory chemicals may result in serious injury.

Where to Go for More Information

New versions of this manual may be available under "Service and Support" on CETAC's Web site:

www.cetac.com

In addition to the *LSX-213 Laser Ablation System Operator's Manual*, you can refer to the following resources for citation material or for further information:

- "Safe Use of Lasers" (Z136.1)

  American National Standards Institute (ANSI)
  11th West 42nd Street
  New York, NY 10036
  Phone: (212) 642-4900
  www.ANSI.org

- "A Guide for Control of Laser Hazards" (Publication 0165)

  American Conference of Governmental and Industrial Hygienists (ACGIH)
  6500 Glenway Avenue, Bldg. D-7
  Cincinnati, OH 45211
  Phone: (513) 661-7881
  www.ACGIH.org

- Occupational Safety and Health Administration (OSHA)

U.S. Department of Labor
200 Constitution Avenue NW
Washington, DC 20210
Phone: (202) 523-8148
www.OSHA.gov

- "Performance Standards for Laser Products"
  United States Code of Federal Regulations
  21 CFR 1040.10(d) and 1040.11.
- The CETAC *LSX-213 Laser Ablation System Service Manual*.
- CETAC Technologies Customer Service and Support:
  Phone: 1 (800) 369-2822 (USA only)
  1 (402) 733-2829
  Fax: 1 (402) 733-1932
  E-mail: custserv@cetac.com

Preparing for Installation

Ventilation

Allow at least 5 cm clearance on all sides of the instrument for ventilation.

CAUTION Do not operate the instrument if the cooling fans are blocked or obstructed in any manner.

2 Using the LSX-213 Laser Ablation System

The LSX-213 system is both reliable and easy to use. Before using the LSX-213 system, however, ensure that your lab environment provides operating conditions that will prolong the life of the LSX-213 system. Once the proper operating conditions are met, you can load samples and perform analysis with the laser ablation system.

This chapter explains how to create the proper operating conditions for using the LSX-213 system. It also explains laser safety precautions, how to prepare and load the samples, start and shut down the laser ablation system, analysis procedures and initial operating parameters.

Establishing Optimal Operating Conditions

The LSX-213 system operates reliably even under less than ideal conditions. It is not, however, indestructible. Malfunction or damage can occur if specific operating conditions are not met. Meeting these conditions requires that you create the proper lab environment, replace laser ablation system components that wear out under normal use and purchase the appropriate supplies for use with the laser ablation system. The following sections explain how to meet these conditions.

> **NOTE:**
>
> Damage or malfunction that results from unsatisfactory operating conditions may constitute misuse and abuse and be excluded from warranty coverage.

Creating the Lab Environment

To create satisfactory operating conditions in your lab environment, follow these guidelines:

- Operate the LSX-213 system in a conventional lab environment where the temperature is 50–85 °F (10–30 °C); the humidity is 20–70% non-condensing; and the unit is not exposed to excessive flammable or corrosive materials.
- Avoid rough handling of the LSX-213 system. Do not expose the laser ablation system to vibration or shock.
- Protect the LSX-213 system from long-term exposure to condensation, corrosive materials, solvent vapor, standing liquids, liquid spills into the electrical equipment or operation inside an acid hood or glove box. Exposures of this type can degrade the optics, corrode and damage mechanical drive mechanisms, as well as the electronics.
- Observe the same general electrostatic discharge precautions as with any other integrated circuit electronic devices. Low humidity environments, especially when combined with static-generating materials, require maximum care.

CAUTION

Discharge static buildup and ground to the laser ablation system base or LSX-213 system cabinet before performing any maintenance. Do not touch or short-circuit bare contacts of any communications ports.

- Avoid exposing the LSX-213 system to high levels of electromagnetic or radio frequency interference (EMI/RFI), or radioactivity. EMI/RFI can cause erratic operation, high levels of radioactivity may cause electronic component failure, and will prohibit factory repair if so contaminated.

Contact CETAC Technologies for assistance if the LSX-213 system will be required to operate in a hostile environment.

Replacing Laser Ablation System Components

The following LSX-213 system components wear out, or become contaminated under normal use, and must be replaced periodically.

- System Tubing
- Chiller water
- Laser flashlamp
- Chiller de-ionizer

If you fail to replace these components when they deteriorate, the laser ablation system will not function properly.

Purchasing Supplies

Because the usage rate of consumable materials and the life span of expendable components will vary, you should maintain an adequate supply of spares. When you need to purchase additional supplies, it is important that you choose the appropriate components and materials. A one-year consumables kit is available from CETAC.

When you purchase replacement parts or consumable supplies, make sure they meet the following requirements:

- Use only distilled water (not 18MΩ laboratory water, bottled distilled water works best) when changing coolant. Tap water or any other coolant will leave deposits in the cooling system, may damage the cooling unit or laser head, or cause other malfunctions.
- Do not attempt to use a substitute laser flashlamp; otherwise, leakage and laser head damage will result. Service only with an exact replacement.

CAUTION

Only a factory trained service engineer should do laser flashlamp replacement. Contact CETAC Technologies at 800-369-2822 or 402-733-2829 for more information, or a certified laser system technician.

WARNING

Use of unsuitable coolants, consumable supplies or inferior replacement parts may result in laser ablation system malfunctions, ICP malfunctions, invalid analysis results or hazardous conditions. Be sure all replacements meet the specified requirements.

To order additional supplies, contact the CETAC Technologies Customer Service department.

Connecting the Laser Ablation System

WARNING	**Two people are required to lift the unit. Lifting should be done with a person situated on either side of the instrument.**

Connections to the Host Computer

Assuming that the LSX-213 has been installed by a qualified CETAC representative, the electronic connections from the host computer to the LSX-213 should already be in place. These include the 52-pin control cable, the RS232 cable to COM 1 (or USB if desired) and the BNC coaxial video cable from the video card on the computer to the video out port on the back of the LSX. If the system is being self-installed, contact your CETAC representative for detailed installation instructions.

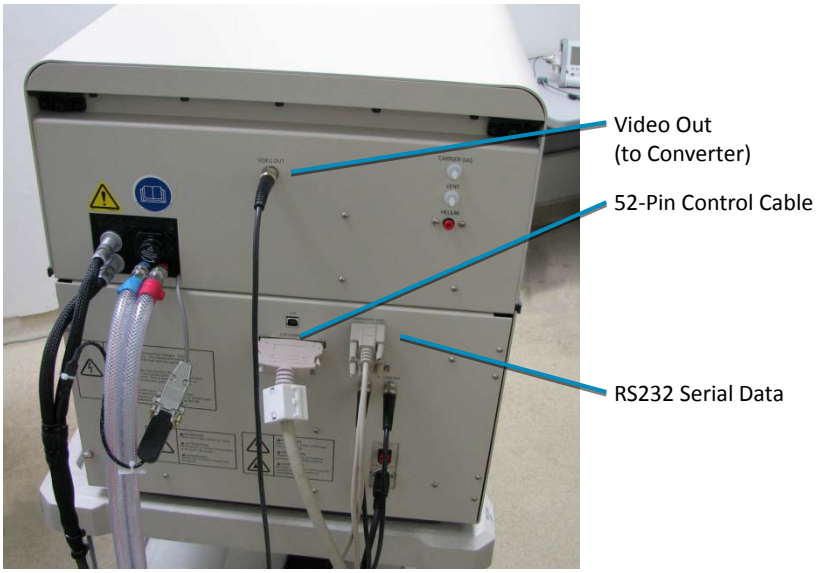


Figure 2-1 Connections to Host Computer

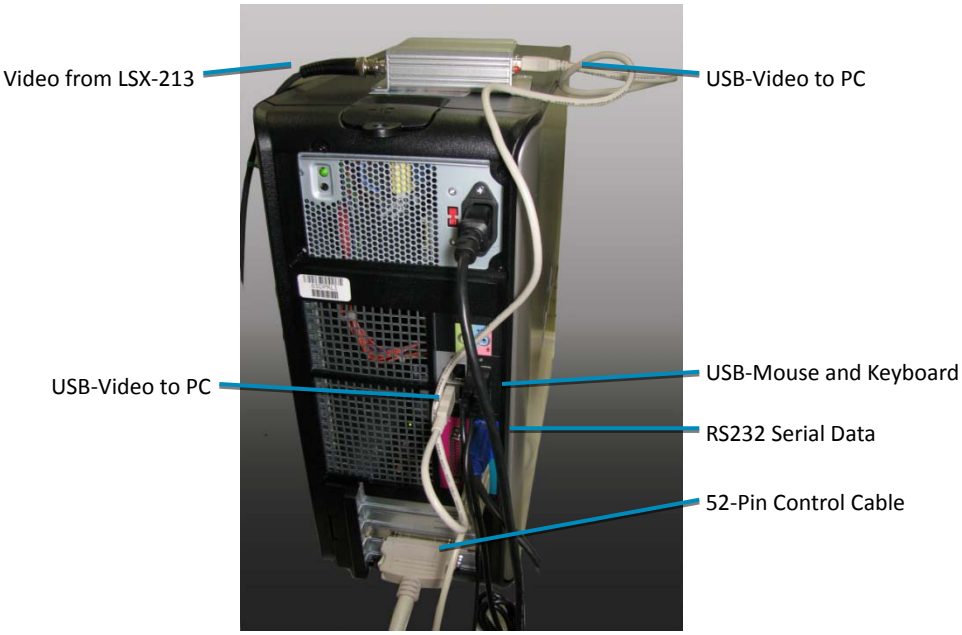


Figure 2-2 Host Computer

Connections to the Power Supply/Cooler

Likewise, all connections between the Laser and the power supply should be in place including the water lines, the primary power cable connecting the power supply and laser, the RS232 cable from the power supply to the laser, the BNC coaxial connecting the "remote link" connector on the power supply to the "Laser Safe" connector on the laser and another BNC cable connecting the "Q-switch sync" on the power supply to "Q-switch" on the laser.

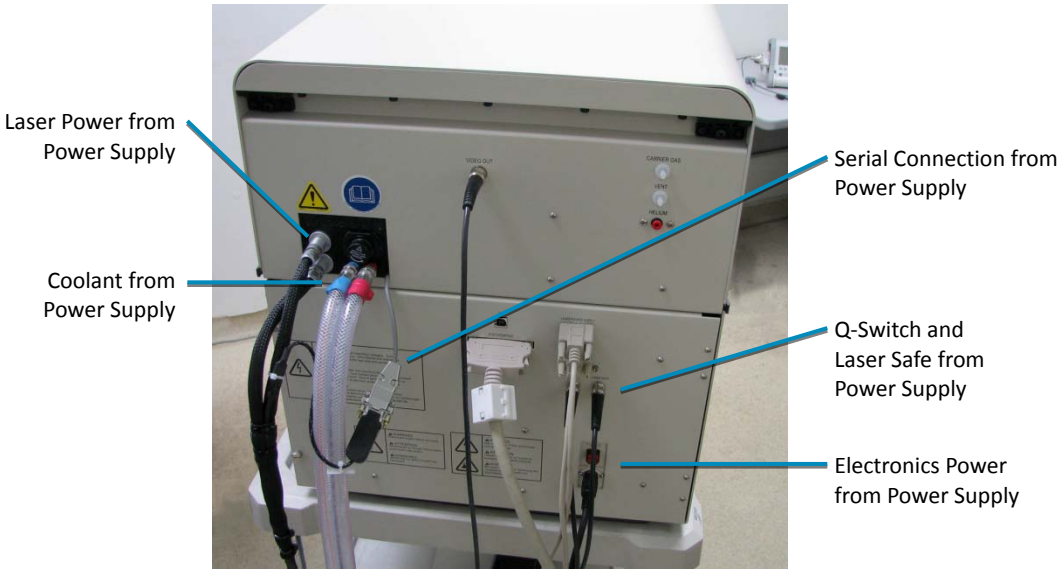


Figure 2-3 Connections to Power Supply/Cooler

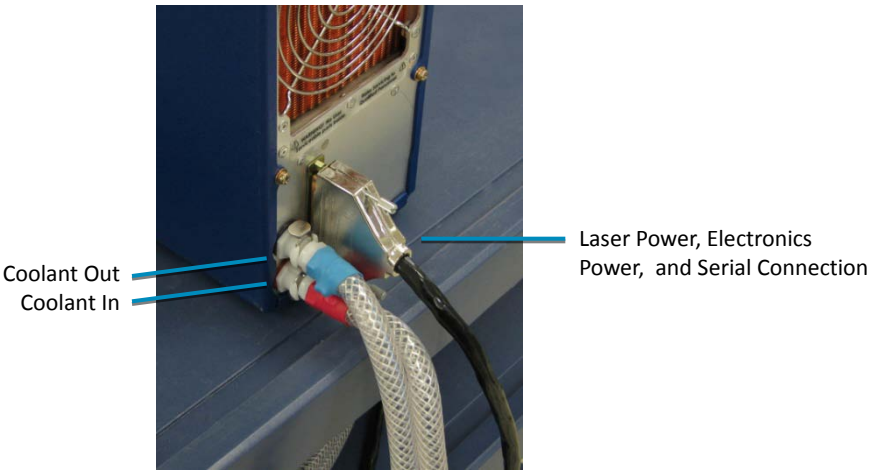


Figure 2-4 Power Supply/Cooler

Gas Connections

The LSX-213 uses both argon and helium during operation. The argon source is from the nebulizer gas from the host ICP. Using the tubing and fittings supplied to connect the nebulizer gas out port on the ICP to the "Argon" port on the back of the LSX-213. For the helium connection, use the supplied fittings to connect 1/8" tubing from the source to the push fitting on the rear of the laser. The vent port may be left open to atmosphere unless very hazardous material is being used which would require complete containment of residual sample material.

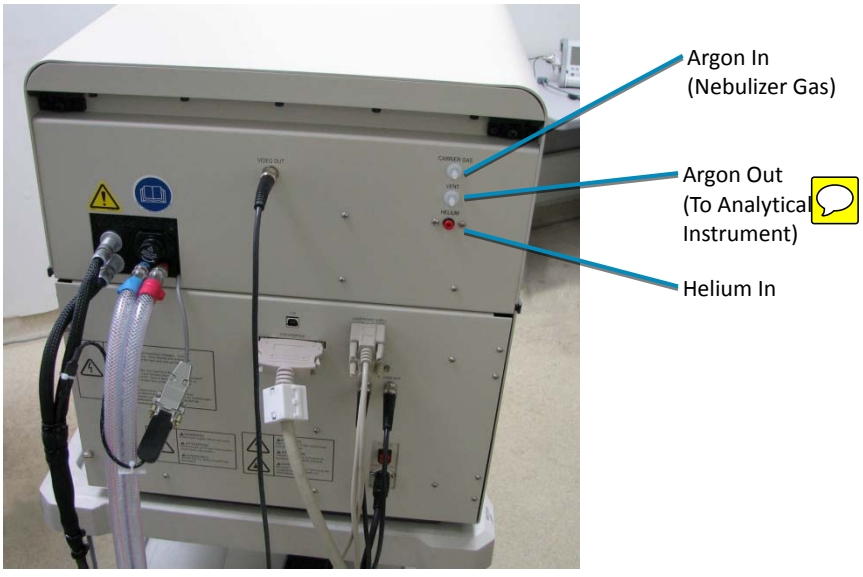


Figure 2-5 Gas Connections

Using the Laser Ablation System

Front Panel Indicators

Status Indicator: LED located on upper front left of the LSX-213 system. Informs the operator of the current instrument conditions as follows:

- **LED Lamp Off**: Interlocks are **NOT** enabled; it is **NOT** safe to fire the laser at this time. Also, the **FAULT** lamp located on the laser power supply is illuminated. For example, the laser system is not powered up.
- **Green LED Lamp**: Interlocks are all enabled, the translation stage is static or being moved into position; the laser system is ready to begin and it is safe to fire the laser at this time.
- **Red LED Lamp**: System interlocks are enabled, translation stage is either static or is moving and the laser is firing.

Starting the Laser Ablation System

After the sample is loaded, laser operation and sample positioning parameters defined, the LSX-213 system is ready to begin operation under computer control until the programmed sampling procedure is completed.

WARNING

Do not start the LSX-213 system unless the front door and top cover of the LSX-213 system are completely closed and all covers and safety interlocks are in place and operating.

To start the laser ablation system, complete the following steps:

1. Turn the main power on.

   The main power switch is the red push-button located on the back panel of the LSX-213 system.

2. Turn the LSX-213 system laser power supply on.

   Make sure to turn the emergency stop button (large round button) on the power supply handheld controller is disengaged (turn counter-clockwise to release the button)

   The power keyswitch is located on the front of the laser power supply. The cooling system is thus initiated as well.

3. Turn the LSX-213 system host computer on and start the DigiLaz III software.

   The system will now initialize, this takes about a minute.

4. Turn on the sample cell illumination lamp.

   Using the top or bottom illumination control, adjust the sample beam intensity.

5. Open the LSX-213 system door and slide out the translation stage.

   Open the LSX-213 system door fully, slide the translation stage out and smoothly pull forward to slide the translation stage out of the LSX-213 system.

6. Load the sample into the sample cell.

   Remove the sample cell by turning counter-clockwise. Place the sample, such as NIST 612 glass standard for system optimization), on the Teflon or transparent sample holder. Replace the sample cell top and ensure that is

secure and air-tight by turning it clockwise until snug (≈ 1/4 turn). (A very light coating of vacuum grease will ensure a tight seal and prolong the life of the O-ring.)

7 Slide the translation stage back to the home position and close the LSX-213 system door.

The translation stage will latch in place when returned to the home position, as will the LSX-213 system door. Failure to fully return the translation stage, or close the LSX-213 system door, will cause interlock faults and prevent system operation. Once in place, the system will purge the cell to remove entrained air from the cell prior starting the plasma. Typically, the purge time is set to 30 seconds, however, the use of non-standard cells may require longer purge times.

8 Begin method setup using the DigiLaz III software by selecting a method from "Method Selection" section of the main software screen.

Once the analysis type and area are defined, ablation can begin. The LSX -13 System will operate under computer control until it reaches the end of the sampling procedure, or it is interrupted by pressing the "Stop" icon.

See "Using the DigiLaz III Software" beginning on page 29 for more information about setting the laser's operating parameters and drawing method graphics.

WARNING

DANGER - INVISIBLE LASER RADIATION. The LSX-213 system is an enclosed, Class I laser system. It uses a Class IV Nd:YAG Laser. The output beam is, by definition, a safety and fire hazard. Precautions must be taken during use and maintenance to prevent accidental exposure to direct or reflected radiation from the laser beam.

Methods of Analyses

The LSX-213 system performs bulk analysis, feature analysis, surface mapping, and depth profile analysis. Many other applications can be developed to encompass user specific goals. Often, one or more methods together to generate data that can only be obtained by using laser sampling. For example, analysis of features and inclusions in geological material.

Typical detection limits of 1-10 ng/g can be expected for most elements using the LSX-213 system coupled to an ICP-MS. Detection limits for ICP-OES systems are generally higher, in the range 0.1-1 ppm. Detection limits are based on sample matrix and sensitivity of the host ICP or ICP-MS. Several laser ablation methods are provided in the DigiLaz III software and controlled by the LSX-213 system (see "Software Methods" on page 51 for method descriptions.)

Optimization

The host ICP or ICP-MS is optimized in concert with each laser ablation program. The LSX-213 laser ablation parameters can be optimized using the following general procedures.

1. Place a homogeneous reference material (such as the NIST 612 glass which is supplied) in the ablation cell. Other suitable reference materials can also be used.

2. Using the Single Line Scan laser ablation method, set up a line across the sample surface using laser parameters that are similar to the types of analysis that you are performing.

   For example, if analyzing samples using a scan rate of 10 µm/sec and 100 µm spot size, use these parameters for optimization of the host instrument.

3. Set the helium flow to 600 mL/min (typical values 500-700 mL/min).

   All other laser parameters should remain the same between samples and tuning. This includes spot size, energy and pulse rate. Optimize the ICP-MS system using typical hardware settings such as nebulizer gas, ion optic voltages and torch/interface parameters.

The LSX-213 system and host ICP-MS are now ready for analysis.

Optimizing the laser system for ICP-OES analysis requires that different procedures be used. For example, specific matrices are analyzed for a major element and the ICP system can be "tuned" to provide desired data quality. Typically, this is done in single line scanning mode in a similar fashion to ICP-MS optimization.

> **NOTE:**
>
> The steps noted above vary greatly depending upon the type of ICP-MS or ICP-OES. Consult the appropriate operating manual for details on tuning and optimizing the instrument.

Bulk Analysis

Bulk quantitative analysis is a common application that is well suited to laser ablation sample introduction. Bulk analysis can be performed on ICP-OES or ICP-MS systems and is largely dependent on the desired level of sensitivity of particular application. The following general scheme can be used to perform accurate and precise quantitative analysis

1. Select a set of homogeneous reference materials to be used for calibration standards and quality control check samples. The standards and samples should be matrix matched as closely as possible while using an internal standard to correct for differences. The internal standard improves the precision greatly and should always be used when possible.
2. Create a suitable quantitative analysis method on the ICP-OES or ICP-MS system. For example, use integration times or dwell times that will collect data for 1-2 minutes of sample ablation.
3. Set up the LSX-213 in one of the methods that sample a large area (either grid of spots, scanning area or line scan) that will be about 30-60 seconds longer in duration to allow the laser ablation system to equilibrate.
4. Optimize the laser pulse rate, helium flow, spot size and scanning rate to achieve the desired sensitivity and stability.

   Typical settings for maximum stability and sensitivity in a line or area scan are:

   Pulse Rate: 20 Hz

   He flow: 500-700 mL / min (optimized in concert with ICP neb flow)

   Spot size: 100-200 µm

   Scanning rate: 20-50 µm/sec

> **NOTE:**
>
> Often, several iterations of method development are required to produce precise and accurate results. The LSX-213 should be optimized in concert with the host ICP system to make certain that the best laser method has been developed.

Elemental or Spatial Mapping

Laser ablation sampling can be used effectively to provide spatial information within and on the surface of the sample matrix. The DigiLaz III software has been developed to make this task very simple. Most frequently, the rastering and single point ablation methods are used for introducing sample aerosols generated by a specific number of laser shots, however, the scanning or rastering methods can also be used. Data is collected as element signal intensity vs. time so spatial or elemental maps can be created to show trace and major elemental variations as a function of matrix.

1. Select the appropriate laser ablation method.

2 Optimize the ICP or ICP-MS system to produce desired mapping elements in the format of time resolved mode.

3 Adjust laser parameters pulse rate, spot size and energy to suit the application and desired data quality.

Depth Profiling

Using the LSX-213 system for measuring matrix analyte concentration as a function of depth into the sample is termed depth profiling. Laser sampling coupled with ICP-MS has found many new applications areas in semiconductor, pharmaceutical and materials research. Depth resolution will vary widely depending on material, but with experimentation one can arrive at a µm depth/ laser shot. Applications that benefit the most from using this laser method are those that have the ICP-MS detection ability to gather many data points very quickly (e.g. TOF ICP-MS). The LSX-213 system can be setup to perform large spot sizes at low repetition rates in order to facilitate analyte measurement with fine spatial resolution. The depth profiling method is designed to provide the operator with maximum sampling flexibility using a step-wise method that can vary the spot size and z-stage movement in an orderly fashion. We have coined this procedure gradient depth profiling. Gradient profiling allows the operator to selectively ablate contaminants from the sample surface followed by concentrated power density drilling into a feature or inclusion. The following general steps can be used to setup a depth profiling application.

1 Using the depth profile method, select a point or several points to ablate by clicking directly on the sample image.

2 Program the desired number of profile steps, energy, spot size, time for each step, and Z-Travel, (Z-Rate will be calculated automatically from the Z-Travel and Time values—the lower limit is 0.25 micrometer/second). The program will begin with the first step and cycle through the entire sequence changing the spot size with each step. This is one method to create cascading craters using the uniformity of the flat-top beam profile.

3 Typically, profiling applications are performed on ICP-MS systems however; some simultaneous ICP-OES systems have the ability to collect data using fast integration times. The ICP-MS should be set to collect a number of elements using short integration times in time resolved mode. Data can then be manipulated to provide informational graphs of signal versus depth and so on. Spatial maps can also provide useful representations as well.

NOTE:

The key laser parameters for effective depth profiling are laser spot size and frequency. One optimization goal is to thoroughly investigate the effect of changing these parameters based on matrix type. In this manner, thin films and coatings tend to behave better at low frequencies (4-5 Hz) while thicker coatings can be profiled at higher repetition rates.

Sample Preparation

With the LSX-213 system, sample preparation is minimal and no wet chemistry is involved. Only sample size, samples with extremely poor surface conditions, and powder samples need preparation.

CAUTION	Incorrectly preparing the sample for laser ablation, particularly powder samples, can result in poor sample ablation and analytical results.

Sample Size

Sample sizes are limited only by the sample cell design, which has been calculated to be large enough for practically all potential applications for the LSX-213 system. Sample sizes ranging from a fraction of an inch to 2 inches (52 mm) in diameter can be placed directly into the sampling cell without further preparation.

Size reduction can be used to decrease sample size so that they will fit into the standard ablation cell. Nominally, this dimension is approximately to 2 inches (52 mm) across.

NOTE:

CETAC offers a full line of ablation cells including an oversize cell (for samples than 2 inches [50 mm] in diameter) , a spring cell (also called the paper cell for document analysis) and a thin-section holder.

Surface Conditions

For most samples, surface preparation is not necessary or recommended. Most sample surface preparations such as grinding, cutting, and polishing may introduce contamination. Only those samples with extremely uneven surfaces and intended for bulk analysis should be cut and ground.

Pre-ablation can be used effectively for samples with grossly contaminated or corroded surfaces. Pre-ablation is performed by using the scanning or raster-mode programs, just as if the sample were being analyzed but at reduced laser power, typically at 60-70%. This operation provides a clean surface for the analytical scan without ablating excessive amounts of material.

Powder Samples

Powder samples must be prepared to prevent large quantities of dust from "blowing" around the sample cell. Many powders will press adequately without the use of a binder material. Avoiding the use of the binder prevents contamination and simplifies sample preparation. Powder samples are compacted into a solid pellet using a pellet press. The compacted pellet may then be analyzed, just as other type of solid material. To avoid problems when making powder sample pellets:

- Select a pellet press capable of producing at least 10,000 PSI (70,000 kPa) compaction pressure. Loosely compacted pellets may break apart during ablation and provide poor or invalid analytical results. Select a die for the

press that is adequate for the application. 13 mm or 31 mm stainless dies are most commonly used.

- For best results the powder should be ground as finely as possible. Grain sizes of less than 1-5 μm provide the best results for pressed pellets.

CAUTION Do not compress volatile or dangerous powders. Please read the MSDS sheet prior to compressing unknown powders and other solid materials.

In the event the ablation cell window becomes cloudy over time, it needs to be cleaned or replaced. The window is glued to a removable plastic mount which is sealed and held in place by an O-ring. The entire mount can be removed by applying forward pressure from the inside of the sample cell top but this is not recommended. To clean, remove the sample cell top and wipe the window and cell clean with water and rinse with alcohol. Wipe dry with a clean wipe. If the window cannot be cleaned using this procedure, a replacement window and mount can be ordered directly from CETAC Technologies.

Shutting Down the Laser Ablation System

To shut down the laser ablation system, complete the following steps:

1. If a laser method is running or if the laser is firing, click on the appropriate stop command.

   When a method is completed, the laser is automatically turned off. If using the manual controls, turn the laser off with the STOP button.

2. Turn the illumination lamp off.

   Set the lamp brightness to zero by clicking the bottom arrow on the light brightness control bars.

3. Exit from the DigiLaz III software and shutdown the computer (if desired)

   Choose File > Exit to shut down the DigiLaz III software.

4. Turn the main power off.

   The switch is located on the back of the LSX-213 system.

NOTE:

Keeping the laser power supply/chiller on for long periods of time does not hurt the system. In fact by continuously pumping water through the laser cavity, the cooling water is much less likely to become contaminated If the system is used more that 2 times per week, it is advisable to keep the power supply running. If the system will be stored for longer than one week, turn off the power supply by turning the key to the off position. If the unit is going to be stored for an extended period, turn the key on the chiller to the off position. Once restarted, allow the chiller to warm up for about an hour to thermally stabilize the system. In the event of extended storage (over 2 months), replace the water in the reservoir with new distilled water. (See "Filling and Draining the Power Supply" on page 67 for instructions.)

3 Using the DigiLaz III Software

Use the DigiLaz III™ software to control the operation of a CETAC LSX-213 or LSX-500 laser ablation system. DigiLaz III allows you to draw method patterns on the screen while simultaneously recording all method parameters and coordinates into a sequence page.

The illustrations provided in this chapter are images that have been taken from the Digilaz III™ program running in a Windows™ XP environment.

What's New

Previous versions of the DigiLaz™ software brought the user an entirely new way of navigating the sample, creating methods and performing sample analyses. The DigiLaz III™ software was developed to enhance the functionality, the flexibility and the user experience of performing laser ablation analyses.

A few new DigiLaz III™ software features include:

- All functionality and control accessible from the main screen
- Sequence Editor with easy import/export options
- New Multiple Line Scan method ideal for surface mapping
- Real-time energy, Z-axis, and Helium software
- Ability to combine various methods in a sequence
- Easy real-time video capture of ablations with/without graphics
- Enhanced triggering capability (contact closure) and options
- Method parameter preferences stored for future use
- Position storage of commonly used sample coordinates
- Fast sample map developer to facilitate visual sample navigation

Software Overview

The DigiLaz III™ Software has eight different types of method operation and several features for manual control of the laser system. These methods include Single Line Scan, Raster, Raster Line, Scanning, Segmented Line Scan, Single

Point, Depth Profile, and Multi-Line Scan. Laser parameter control and modes of operation are accessed by "point and click" usage. The platform is designed for maximum method flexibility by using a drawing mode of displaying a method patterns on the screen while simultaneously recording all method parameters and coordinates into a sequence page.

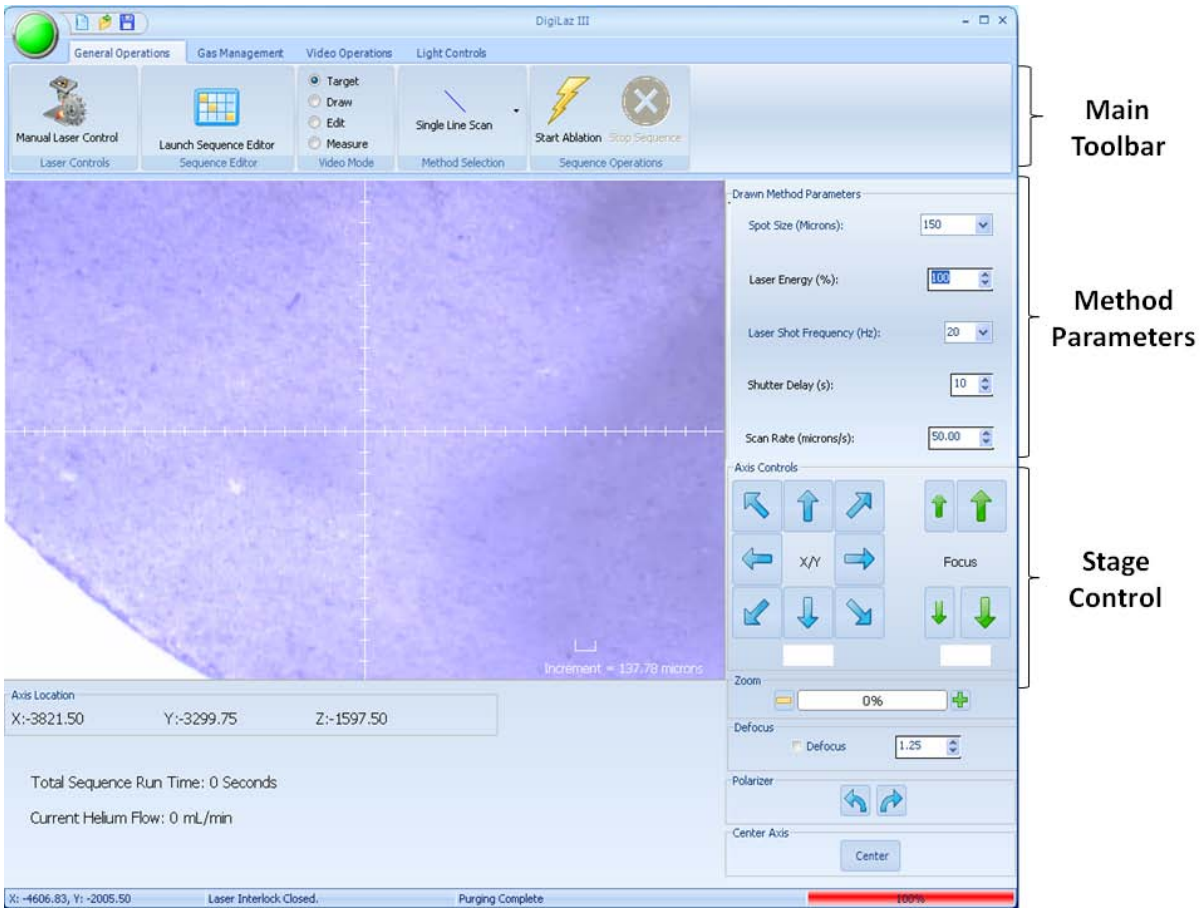


Figure 3-1 DigiLaz III™ Software Main Screen

Installing the DigiLaz III™ Software

If you are installing a complete laser ablation system, the software will be pre-installed on the supplied computer. If you are upgrading the software or if you are using a different computer, follow these instructions:

1. If you have not already done so, prepare the computer and the video adapter according to the document *Installation Instructions for the DigiLaz III Software Package.*
2. Insert the software CD into the host computer.
3. Select the "DigiLaz III installation" folder on the CD.
4. Double click the setup program.

5 At the 'Welcome' screen, click "Next".

6 Read the license agreement, click to accept, and then click "Next".

7 Click "Next" to install DigiLaz III in the default location.

8 Review the installation settings and then click "Install".

9 Wait for installation to finish. It may take several minutes.

10 Click "Finish" to end the installation program. The installation program will offer you the option to launch DigiLaz III.

Running the DigiLaz III™ Software

The first time you run the software, you will need to configure some options:

1 Launch DigiLaz III.

You will initially see a dialog to select your hardware.

2 Select the 'Communications' tab, then select the COM port you have connected your laser to.

3 Click the Laser System tab.

4 Use the menu on the left to select your laser hardware.

5 Use the menu on the right to select the aperture wheel you have. By default, CETAC LSX systems come with a (10, 25, 50, 100, 150, 200, Square) aperture wheel.

6 The Motor Control and Video Card options do not need to be selected.

7 Click Save settings.

DigiLaz III will now launch.

From now on, when the application loads it will automatically establish communication between the computer and the laser ablation system. This includes homing the translation stage, homing laser hardware, and verifying system interlocks. When the program has initialized, the main screen will appear. Figure 3-1 depicts the main screen of the DigiLaz III™ Software.

If you need to access the configuration menu again, click the green button then select Tools>Select Hardware.

Essential Tasks

Emergency Stop

Stopping the Laser Quickly

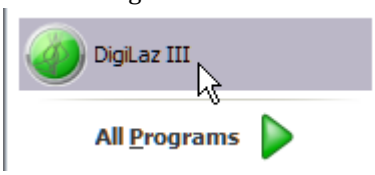
- Press the stop button on the power supply pendant (control pod), or
- Turn off the power switch on the back of the laser ablation system.

In Case of Electrical Hazard

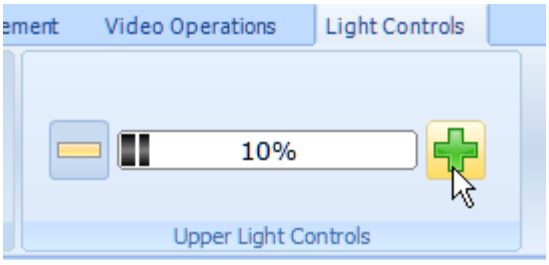
If there is an electrical hazard—for example, if a liquid has spilled into the power supply—unplug the laser power supply and the laser ablation system from the wall outlet.

Starting the Laser Ablation System

1. Check that the front door and top cover of the laser ablation system are completely closed.
2. Turn on the power switch on the back of the laser ablation sytem.
3. Turn the laser power supply on.
4. Turn on the host computer.
5. Start the DigiLaz III software.

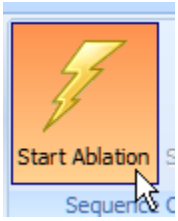


6. Prepare and load the sample.
7. Turn on the sample cell illumination lamp.



8. Set up the ablation method in the DigiLaz III software.
9. Set up the analysis methond in the ICP software.

10 Click Start Ablation.



Shutting Down the Laser Ablation System

To shut down the laser ablation system, complete the following steps:

1 If a laser method is running or if the laser is firing, click on the appropriate stop command. When a method is completed, the laser is automatically turned off. If using the manual controls, turn the laser off with the STOP button.

2 Turn the illumination lamp off. Set the lamp brightness to zero by clicking the bottom arrow on the light brightness control bars.

3 Exit from the DigiLaz III software and shutdown the computer (if desired) Choose File > Exit to shut down the DigiLaz III software.

4 Turn the main power off. The switch is located on the back of the LSX-213 system.

> **NOTE**
>
> Keeping the laser power supply/chiller on for long periods of time does not hurt the system. In fact, by continuously pumping water through the laser cavity, the cooling water is much less likely to become contaminated. See the *Operator's Manual* for more information.

Menus in the DigiLaz III™ Operating Software

General Operations

The General Operations menu consists of several sections: Laser Controls, Helium Flow Control, Sequence Editor, Video Mode, and Sequence Operations.

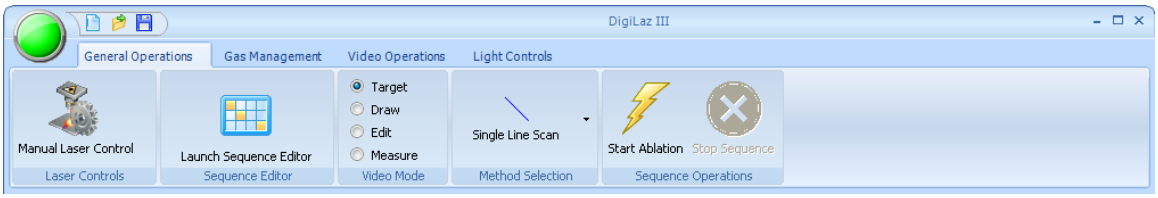


Figure 3-2 DigiLaz III™ Software General Operations Section in the Main Toolbar

Laser Controls: This section contains the "Manual Laser Control" button. When this button is pressed (left mouse click) the following screen will open:

Figure 3-3 Manual Laser Control menu

Table 3-1 Laser Controls

Control	What it does
Spot size (Microns)	Spot size selection
Laser Energy (%)	Energy Level Selection
Laser Shot Frequency (Hz)	Laser Pulse Repetition rate selection
Continuous/Burst	Laser Pulse Mode Selection: Continuous (laser fires until "stop" is pressed) and Burst (allows a fixed number of shots to be fired)
Use Shutter Delay	With this option checked the user can designate the laser warm-up and stabilization time
Open/Close Shutter	After the shutter has opened, the "Open Shutter" button will change to "Close Shutter" allowing the user to toggle the shutter open and closed
Start Laser	Initiates laser operations according to the specified parameters

Sequence Editor: This section contains the "Launch Sequence Editor" button which is used to open the Sequence Editor page. The Sequence Editor is described in detail on page 43.

Video Mode: This section contains four selection choices: Target, Draw, Edit, and Measure.

Table 3-2 Video Modes

Mode	What it does
Target	This selection allows the user to navigate the sample with simple mouse clicks on the graphical interface screen. When a mouse click is made the stage will move such that the graphics screen (or center of the crosshairs) is centered on that point.
Draw & Edit	Allows method graphics to be drawn and edited on the graphical interface screen. This process is described in detail in the Draw & Edit Method Graphics section.
Measure	This selection allows the user to make sample measurements on the graphical interface screen as depicted below in Figure 3-4. This is achieved with a simple left mouse click and drag to designate the start and end points. The measurement tool will give real-time measurements as the measurement line is "dragged" out.

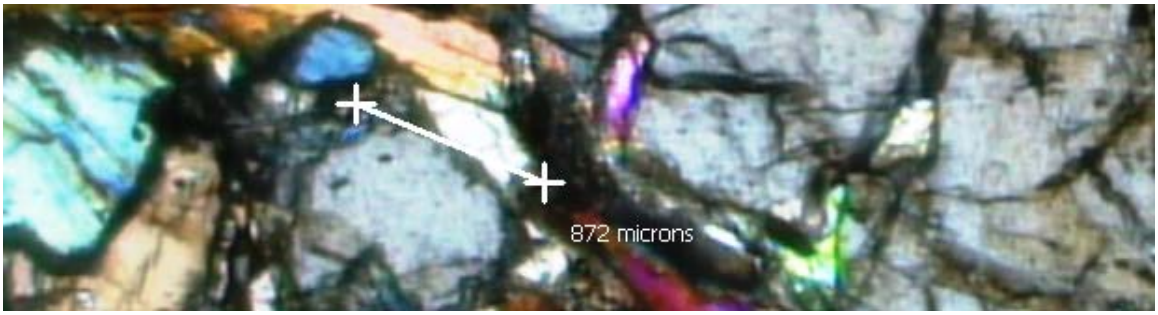


Figure 3-4 Measurement tool showing the distance between two points (shown as + signs)

Method Selection: Here the user can choose the desired method to draw on the graphical interface screen. When this button is pressed a menu appears (Figure 3-5 below) which allows the desired method to be selected.

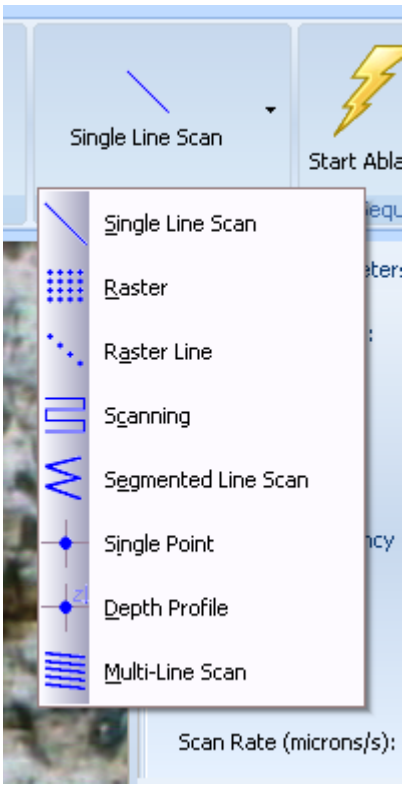


Figure 3-5 Method Selection drop-down menu

Sequence Operations: Here the user can start and stop a method or sequence. When the "Start Ablation" button is pressed, the Sequence Run Information window will open. This window (Figure 3-6) displays the status of all relevant information during a method or sequence and also allows real-time control of energy and laser shot frequency selections using the drop-down menus for parameter selection.

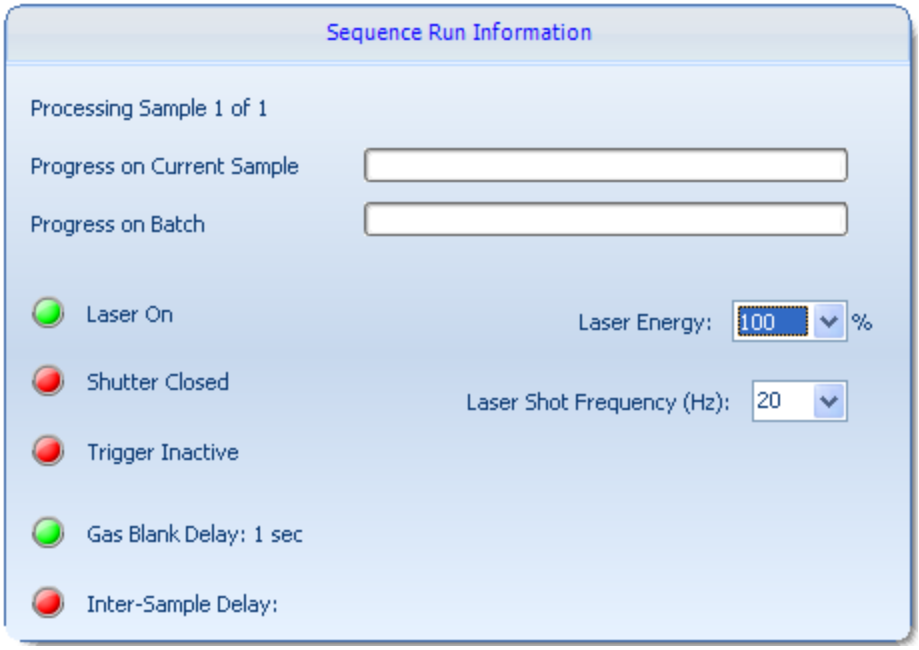


Figure 3-6 Sequence Run Information window

Gas Management

The Gas Management section consists of four sections: Helium Flow Control, Gas Management State, Purge Time, and Cancel Purge.

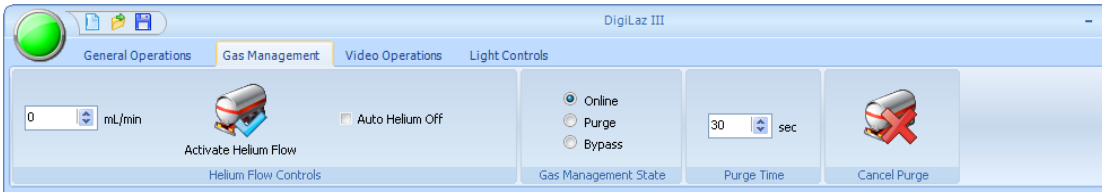


Figure 3-7 Gas Management menu

Helium Flow Control: This section allows a value to be designated for the desired Helium carrier gas flow rate. A value can be manually entered in the ml/min box or the scroll bars can be used to assign one. After the desired setting is chosen, the "Activate Helium Flow" button must be pressed to achieve the desired flow. A unique feature of the DigiLaz III software is that this value can be changed at any time during a sequence run allowing immediate signal feedback for enhanced method optimization.

Gas Management State, Purge Time, & Cancel Purge: This section allows control of the on-board valves used to direct carrier gas flows. In the "Online" state, Helium carrier gas flows through the sample cell and mixes with Argon flow at the valves before exiting through the "Sample Out" port to the ICP or ICP-MS. (See Figure 3-8.)

The "Bypass" state is activated anytime a safety interlock is opened (by opening the sample compartment door or raising the upper enclosure) and is used to divert gas flows away from the sample cell and to the host instrument.

This allows the sample cell to be opened for sample changes without extinguishing the plasma. (See Figure 3-9.)

As soon as the interlock is closed (by closing the sample compartment door or closing the upper enclosure), the valves switch to "Purge" mode. This allows the gas flows to be directed through the sample cell and out the vent port to remove any ambient air before being directed back to the host instrument. The "Purge Time" box can be used to designate a specific purge time and the "Cancel Purge" button can be pressed at any time during the purge to return the valves to the "Online" state. (See Figure 3-10.)

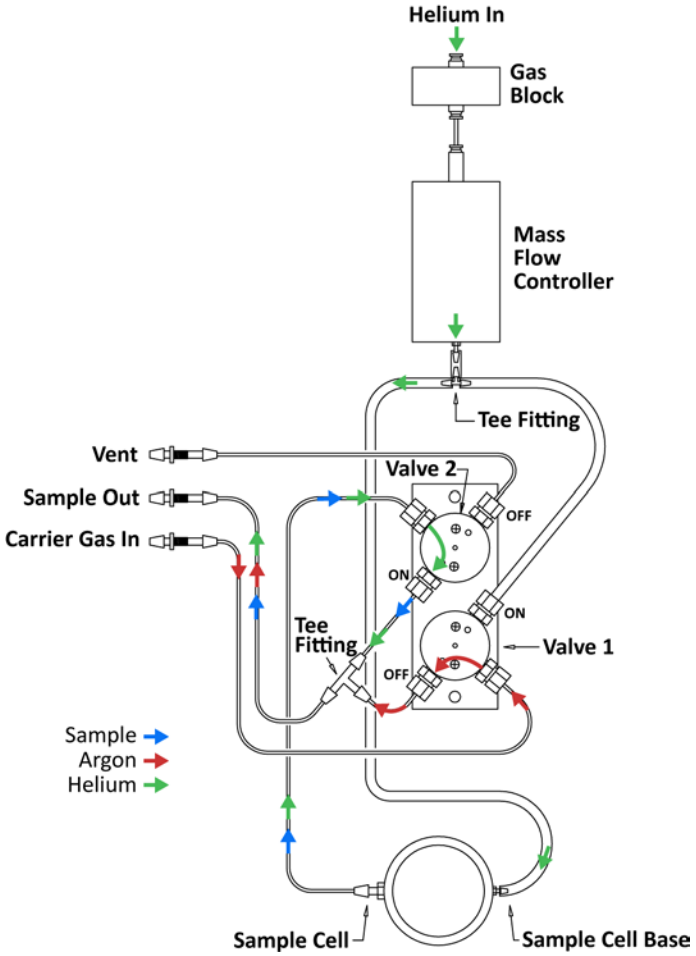


Figure 3-8 Online gas management state

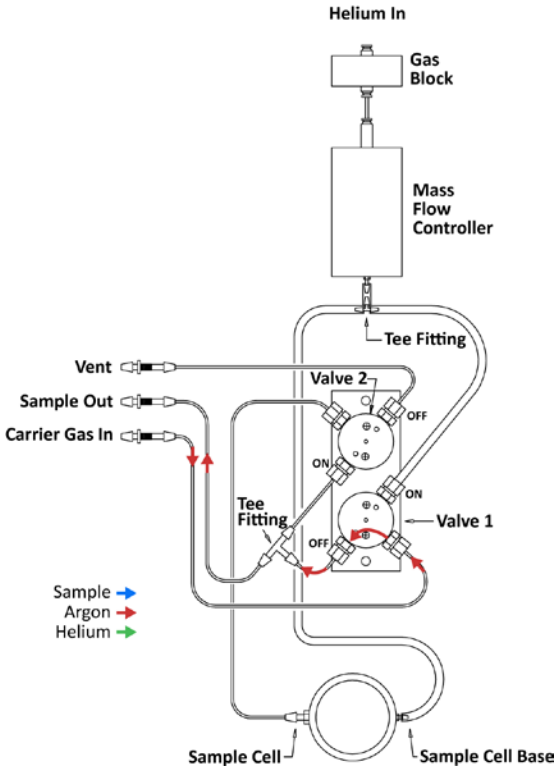


Figure 3-9 Bypass gas management state

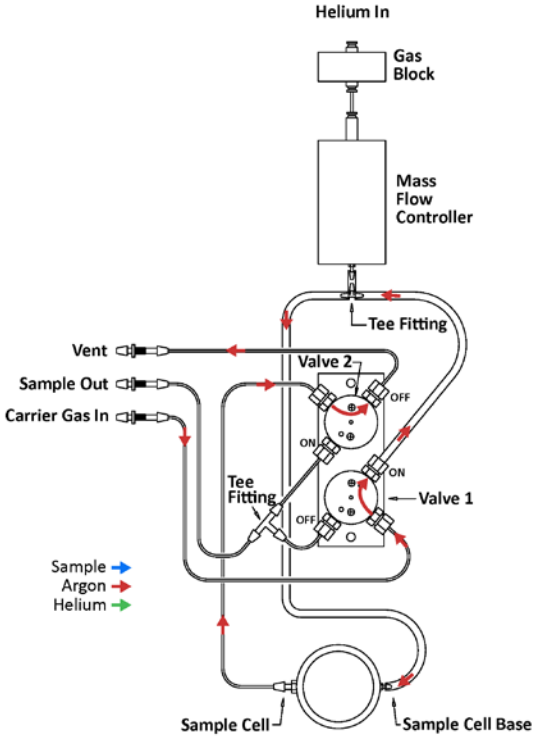


Figure 3-10 Purge gas management state

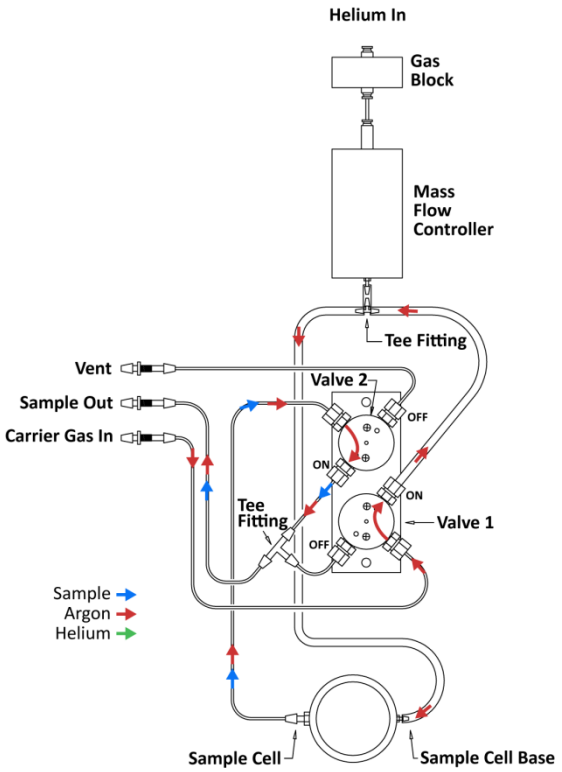


Figure 3-11 Argon-only gas management state (no He flow)

Video Operations

The Video Operations section consists of five sections: Video Stream, Crosshairs, Lines, Media, and Sample Map.

Figure 3-12 DigiLaz III™ Software Video Operations Section in the Main Toolbar

Video Stream, Crosshairs, & Lines: These sections allow control of the video stream, crosshairs, and method graphic displays using a checkbox. The Crosshairs and Lines sections contain a button that can be clicked to control graphic colors as in Figure 3-13 below.

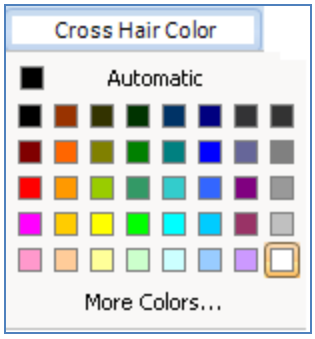


Figure 3-13 Graphic color selection button

Media: This section allows a sample image and/or video to be recorded. To "Video Snap Shot" button can be pressed to capture and save a sample image. The "Begin Recording Video" and "Stop Recording" Video buttons are used to initiate and stop a video recording. In both cases, a "Save As" window will open allowing the user to designate a file name and save location (see Figure 3-14).

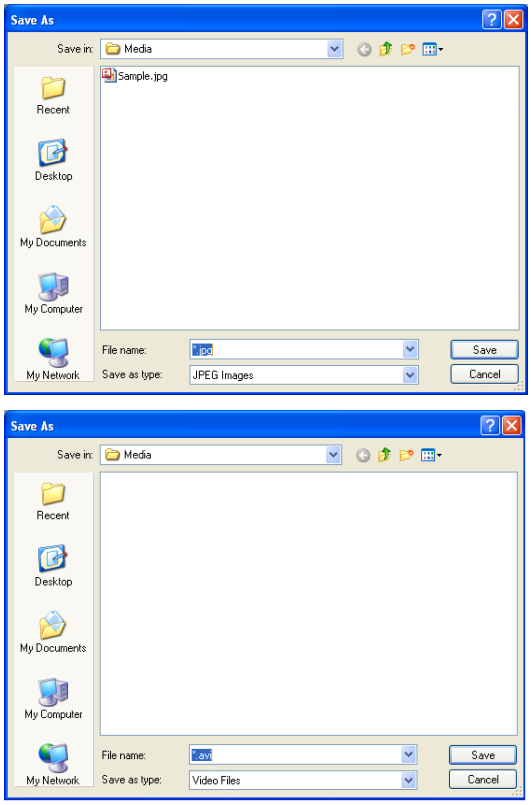


Figure 3-14 Save As windows for Video Snapshot and Begin Video Recording buttons

Sample Map: This section allows a sample map to be created of the entire sample cell area or of a portion. By pressing the "Create Sample Map" button, the window below in Figure 3-15 will appear. In the "Sample Map Operations" menu the user can designate the number of images (more images will result in a larger, higher quality image but will take longer to construct) used to

construct the map and specify the location around which the map will be built (either "Center" of the sample cell or "Current Location"). The "File Operations" menu contains buttons used to save, open, or clear a sample map.

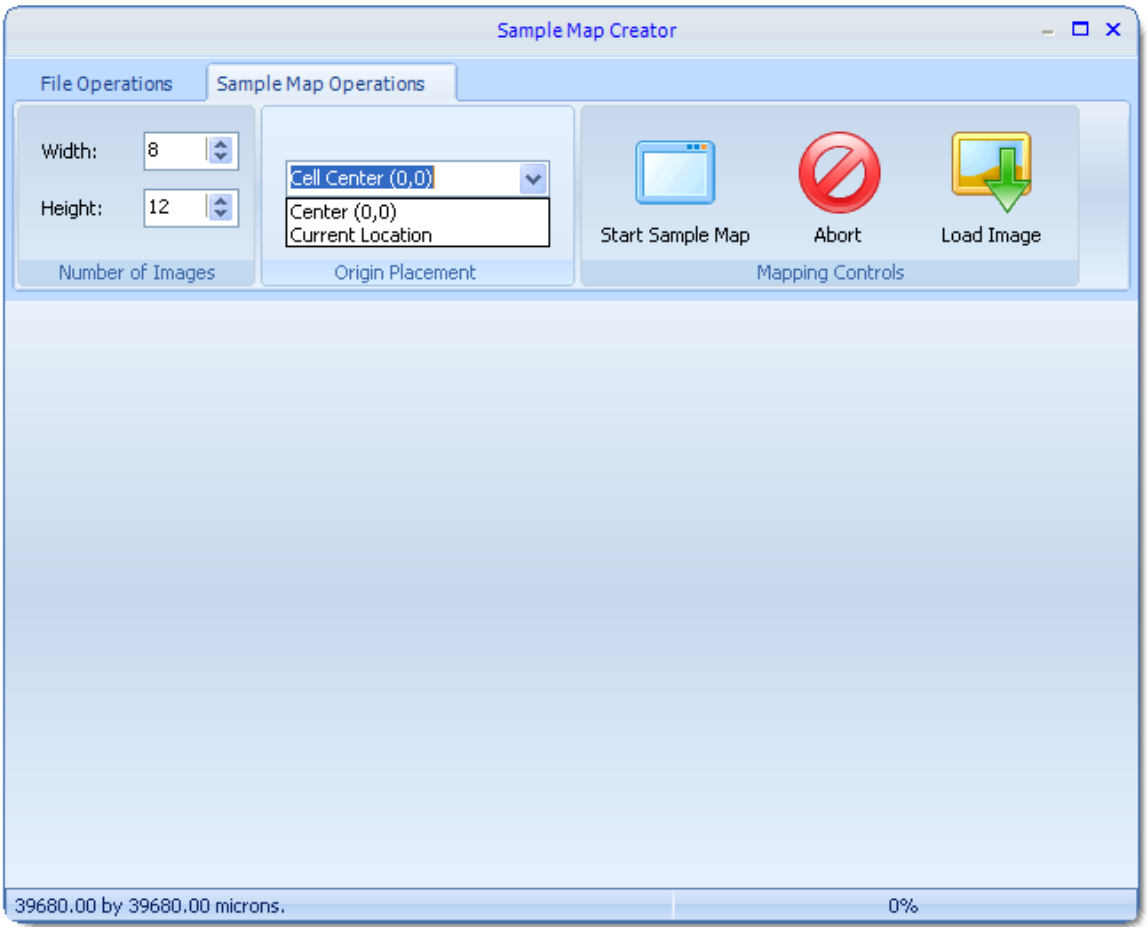


Figure 3-15 Sample Map Creator window used to create sample image maps

Light Controls

The Light Controls section contains controls for upper and lower LED lighting. The user can increase or decrease the percentage of lighting used by clicking the + or – signs or by simply clicking an area within the percentage box.

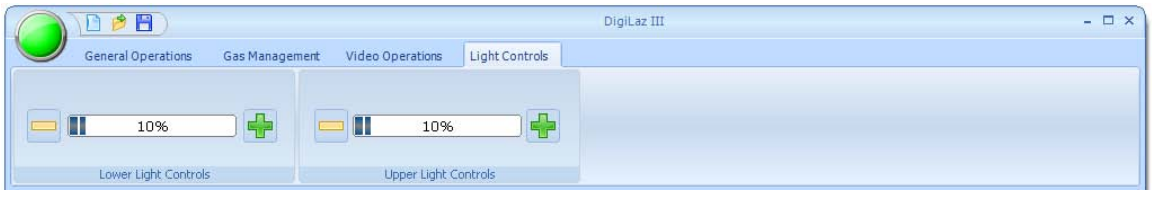
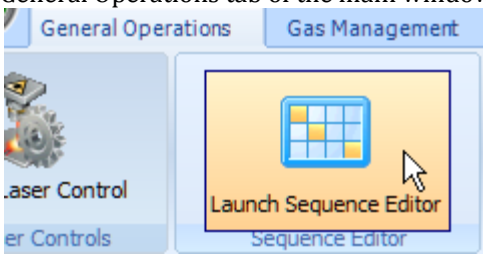


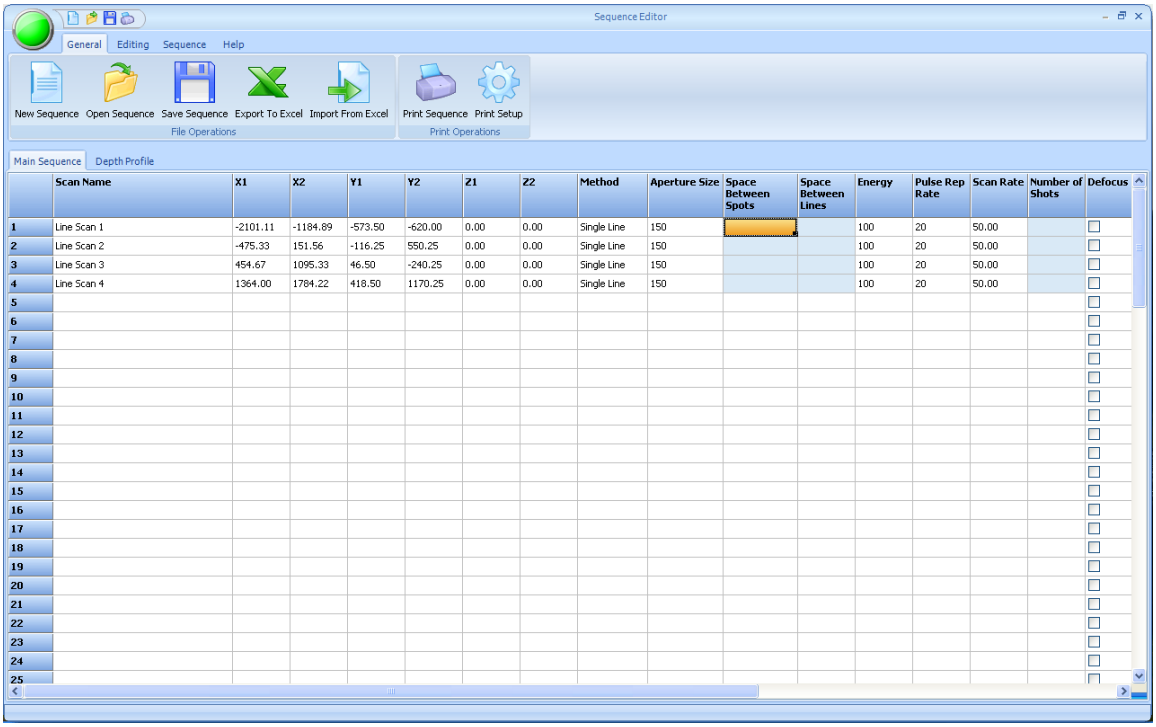
Figure 3-16 Light Controls menu

Using the Sequence Editor

The Sequence Editor opened by clicking Launch Sequence Editor in the General Operations tab of the main window.



The Sequence Editor automatically stores all drawn method pattern coordinates and associated parameters such as spot size, pulse repetition rate, scan rate, etc.



	Scan Name	X1	X2	Y1	Y2	Z1	Z2	Method	Aperture Size	Space Between Spots	Space Between Lines	Energy	Pulse Rep Rate	Scan Rate	Number of Shots	Defocus
1	Line Scan 1	-2101.11	-1184.89	-573.50	-620.00	0.00	0.00	Single Line	150			100	20	50.00		
2	Line Scan 2	-475.33	151.56	-116.25	550.25	0.00	0.00	Single Line	150			100	20	50.00		
3	Line Scan 3	454.67	1095.33	46.50	-240.25	0.00	0.00	Single Line	150			100	20	50.00		
4	Line Scan 4	1364.00	1784.22	418.50	1170.25	0.00	0.00	Single Line	150			100	20	50.00		
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Figure 3-17 DigiLaz III™ Sequence Editor

These parameters can be edited in the sequence editor at any time after a graphic has been drawn on sample image. A change in the sequence editor will automatically be updated on the sample image. For example, if an Aperture Size is changed from 150 to 50 microns in the Sequence Editor, the drawn graphic will change to reflect this smaller size.

When you need even more editing power, it is easy to export the sequence to a Microsoft Excel spreadsheet, edit it, then import the sequence back in to DigiLaz III.

General

The General tab includes two groups of commands: File Operations and Print Operations.

File Operations

This group contains buttons which allow you to create a new sequence, open/save a sequence, and export/import a sequence to and from Microsoft Excel. When the Open/Save Sequence or Export/Import buttons are clicked, a window will automatically open allowing you to Open/Save or Export/Import Sequences. By default Sequences are stored in the Sequence folder located in the following path: C:\Documents and Settings\All Users\Documents\CETAC\DigiLazIII\Sequences.

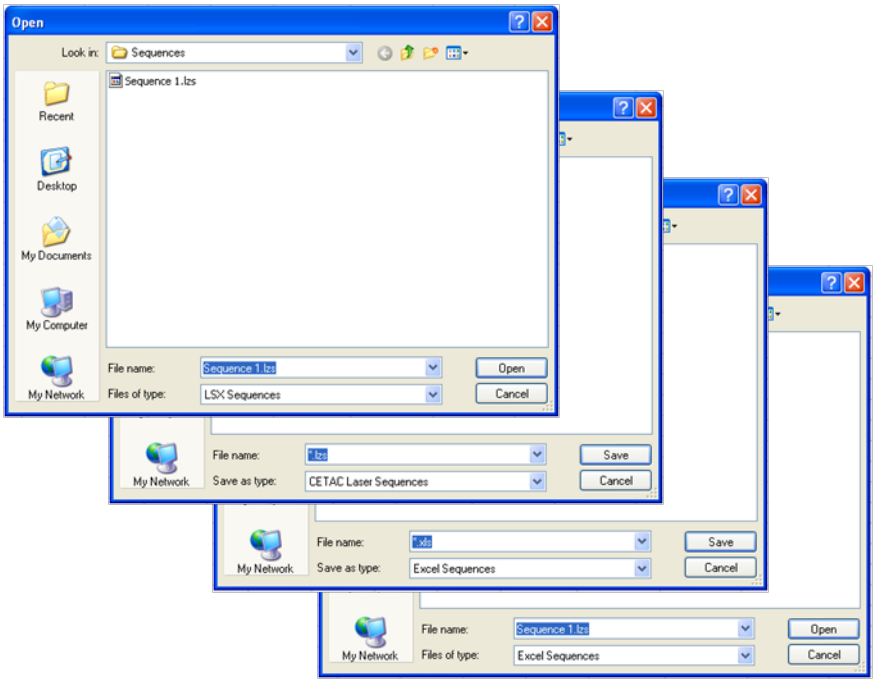
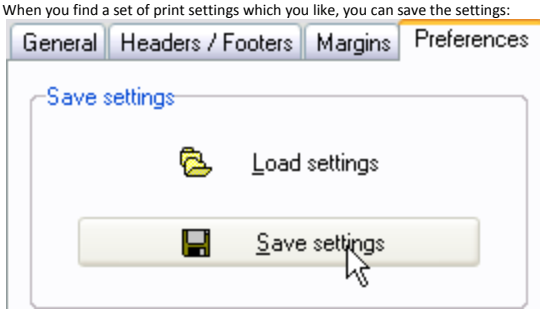


Figure 3-18 Open/Save As windows for Sequence Open/Save and Import/Export functions

Print Operations

This group allows you to print a the sequence. Click Print Setup to configure fonts and page layout, then click Print Sequence to print to the default printer.

When you find a set of print settings which you like, you can save the settings:



Editing

This tab allows features for easily editing various aspects of the sequence.

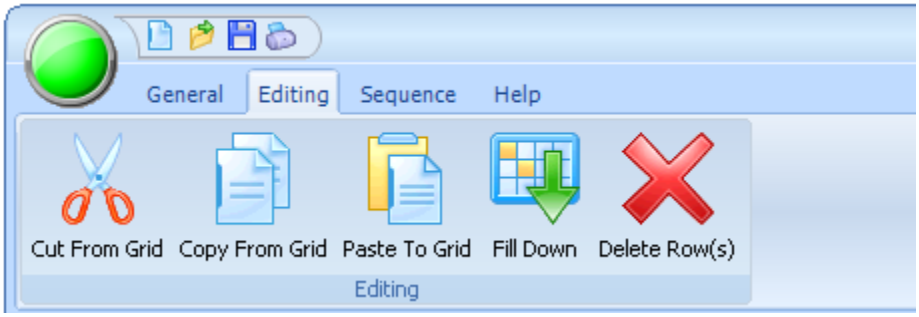


Figure 3-19 DigiLaz III™ Sequence Editor "Editing" menu

These features can either be accessed in the Editing tab by clicking each button individually or by right clicking the mouse.

Sequence

The Sequence tab includes five groups: Sequence Operation, Sample Selection, Batch Selection, Laser Activity, and Total Sequence Run Time. These features can also be accessed by clicking the green button in the upper left-hand corner.

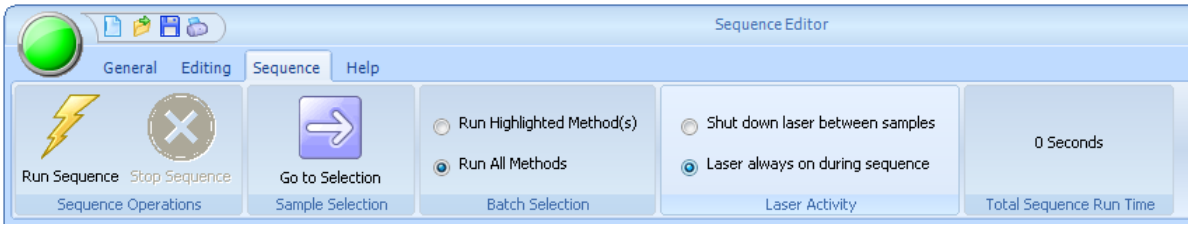


Figure 3-20 DigiLaz III™ Sequence Editor "Sequence" menu

Sequence Operations

In this group a sequence can be initiated or terminated.

Sample Selection

This group contains the "Go to Selection" button. When this button is clicked the stage will move to the start point of the highlighted row in the sequence. This feature makes it easy to locate a drawn graphic on the sample image.

Batch Selection

Here the user can choose to either run the entire sequence or only a portion. Laser Activity: This group allows the user to turn the laser off between samples to prevent wasted shots over time. If the "Shut down laser between samples" option is chosen, an automatic 10 second pause will be enforced between each sample. If this feature is used however it is recommended that at least a 20 second or longer "Pause Between Samples" be used to allow adequate time for warm-up and stabilization of the laser.

Total Sequence Run Time

Displays the total time required to complete the entire sequence.

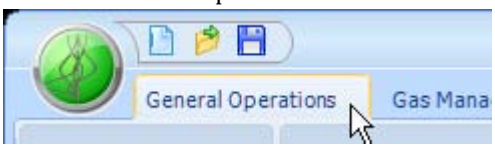
Help

Sequence editor Help is not enabled at this time, but you may access help through the Help button in the main DigiLaz III™ window.

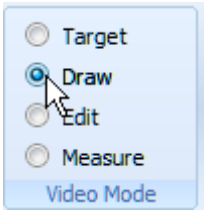
Drawing and Editing Method Graphics

Drawing a Method Graphic

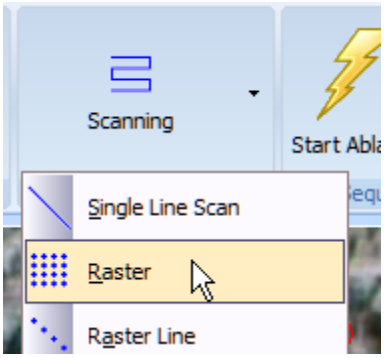
1 Click the General Operations tab.



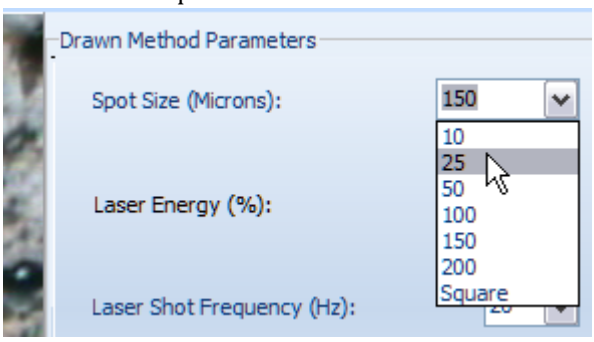
2 Click Draw in the Video Mode group.



3 Select the method.



4 Set the method parameters.



5 Click on the sample image to define the starting point of the method.

6 Continue clicking to set intermediate or end points. See "Software Methods" beginning on page 51 for details.

To mark the final segment for the Segmented Line Scan method, right click and choose Mark Last Segment.

7 Use the Sequence Editor to adjust the parameters.

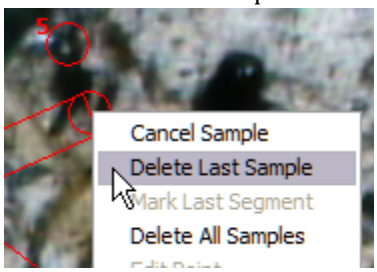
Deleting a Method Graphic

In Draw mode, a graphic in process of being drawn can be canceled before the end point is set by right clicking and choosing Cancel Sample from the menu.

To delete a method graphic immediately after it was drawn:

1 Right-click anywhere on the sample image.

2 Select Delete Last Sample or Delete All Samples.



To delete a previously drawn method graphic, or to delete one point or line segment from a complex method:

1 Click the General Operations tab.

2 Click Edit in the Video Mode group.

3 Right-click on the point or on the beginning of the line segment to delete.

To delete a point or line segment in the Segment Editor:

1 Click on the row number to select the entire row.

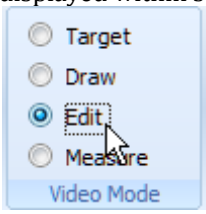
2 Right-click on the row and select Delete Row.

Editing a Method Graphic

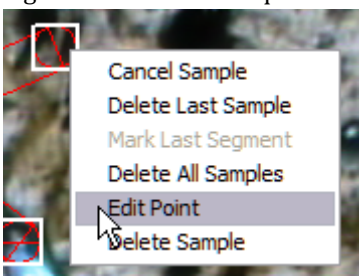
To move a point or the beginning/end point of a line segment:

1 Click the General Operations tab.

2 Click Edit in the Video Mode group. Points which can be edited will be displayed within squares.



3 Right-click inside the square and choose Edit Point from the menu.



4 Move the mouse to the new location and left-click.

Only graphic positions (x,y) can be edited in the main window. Parameters for drawn graphics must be edited using the Sequence Editor.

Setting Method Parameters

For each method, a list of parameters specific to that method will appear in the "Drawn Method Parameters" section of the main window. These parameters will be assigned to any new graphic drawn on the screen for that method. However, once a method graphic is drawn, parameters for that method can only be changed in the Sequence Editor.

Notice that the Scanning and Multi-Line Scan methods are similar to the Single Line Scan method but include an additional box for designating the space between the lines. The Multi-Line Scan method also includes a box to set the number of parallel lines to draw.

Triggering and Timing

The DigiLaz III software can be used to designate when an external trigger signal will be sent to initiate data acquisition by the host instrument. Depending on how the host instrument is configured, the LSX-213 can use contact closure to synchronize start and delays between the LSX-213 and host ICP.

All triggering and timing features are set in the Sequence Editor and include the following: Pause Between Samples, Shutter Delay, Gas Blank, and Trigger Delay.

By default, the trigger signal will be sent when the Gas Blank begins.

Gas Blank

Time that occurs before the laser begins to fire onto the sample. Gas Blank includes the Shutter Delay time, so it must be greater than or equal to the Shutter Delay value.

Pause Between Samples

Includes the Gas Blank time and is used to set the amount of time the laser will wait before ablating the next method.

Trigger Delay

Delays the trigger the specified number of seconds after the Gas Blank is started. Use Trigger Delay to trigger the host instrument to begin data acquisition after the laser has begun to fire on the sample.

Examples

In the example below, a Pause Between Sample of 60 seconds is used. This means after the method in row 1 is completed, the DigiLaz III software will count down 40 seconds and then begin the Gas Blank countdown for an additional 20 seconds to equal the total 60 second pause before ablation of the next method begins. The trigger signal will be sent after the initial 40 seconds has elapsed when the 20 second Gas Blank begins.

	Pause Between Samples	Shutter Delay	Gas Blank	Trigger Delay	Sample Run Time	Total Sample Time	Number of Runs
		10	20	0	27	47	1
	60	10	20	0	38	98	1

In the example below, with a Trigger Delay value of 30 seconds and a Gas Blank of 10 seconds, the trigger signal will be sent 20 seconds after the laser has began to fire. If the Gas Blank value was set to 20 seconds in this example, the signal would be sent 10 seconds after the laser has began to fire.

Pause Between Samples	Shutter Delay	Gas Blank	Trigger Delay	Sample Run Time	Total Sample Time	Number of Runs
	10	10	30	83	93	1

Service Calibration Tools

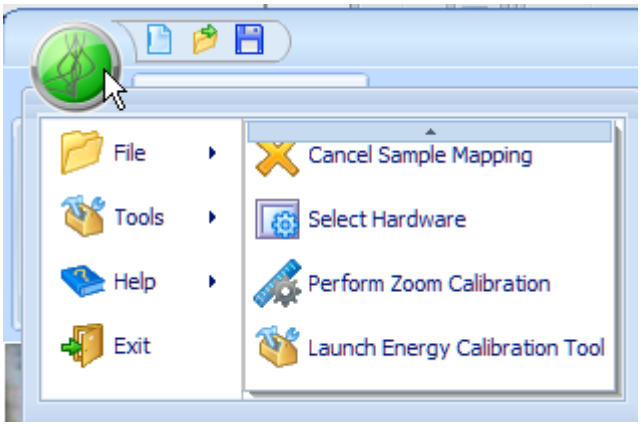


Figure 3-21 Green button used to access service calibration tools

The green button in the upper left corner can be pressed to access some of the features located in the DigiLaz III™ submenus. Two extra functions are only accessible by pressing this green button from the main software screen. These are "Energy Calibration" and "Zoom Calibration" tools. These functions are primarily used by a service engineer to recalibrate zoom steps and energy parameters. As such, these functions are described in another document only available from the CETAC service department. These tools should only be accessed on request of the CETAC service engineer.

4 Software Methods

Each of the pictures shown are taken from the main software screen. Each method can be “drawn” using the graphical interface, as indicated in these pictures, or, by entering the sample coordinates into the sequence editor. On-screen graphical method drawing is useful because one can see exactly where the ablation spot, line or area is going to take place. It is limited however due to the fact that the analytical area must fit into the visible area of the screen. When this limitation must be overcome, manual setting of start and stop positions in the sequence editor should be used. More detailed information can be found in the chapter “Using the DigiLaz III Software” beginning on page 29.

Spot Scan

Description

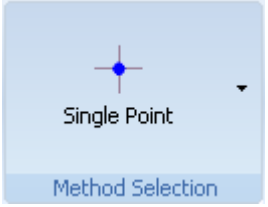
Single point (spot scan) allows the selection of single or multiple spots.

Parameters

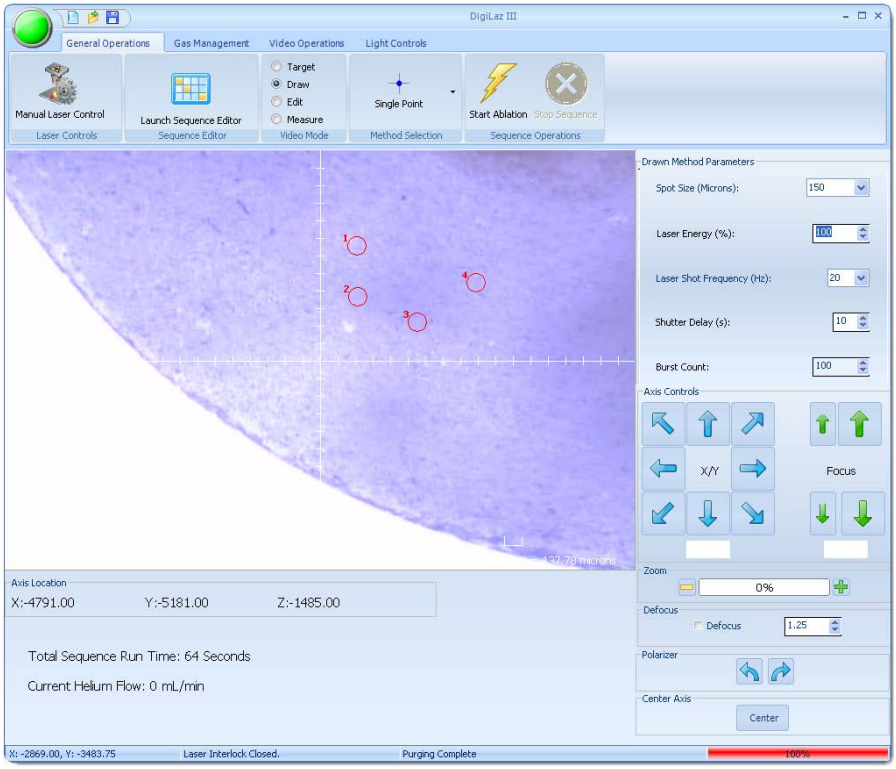
The size of each spot, number of laser shots per spot (Burst Count), energy, shot frequency, and defocus value can be set in the dialog on the mid right section of the main window before each spot is drawn. Also, a pause between spots, gas blank and trigger delay can be set using the sequence editor.

How to Draw

Select the Single Point method then click on the sample image to set the location of the spot. Each spot appears in a user selectable color (red in this case) and can be erased (using the right click menu) and re-set until the method is complete.



Example



Line Scan

Description

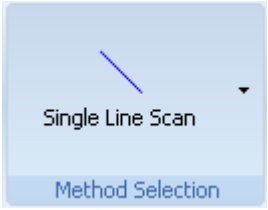
Single line scan allows the laser to move incrementally across a sample in a straight line.

Parameters

Energy, shot frequency, and spot size can all be set. The scan rate, expressed in µm/sec, automatically calculates the time per scan and the X and Y distances traveled.

How to Draw

1 Select the Single Line Scan method.

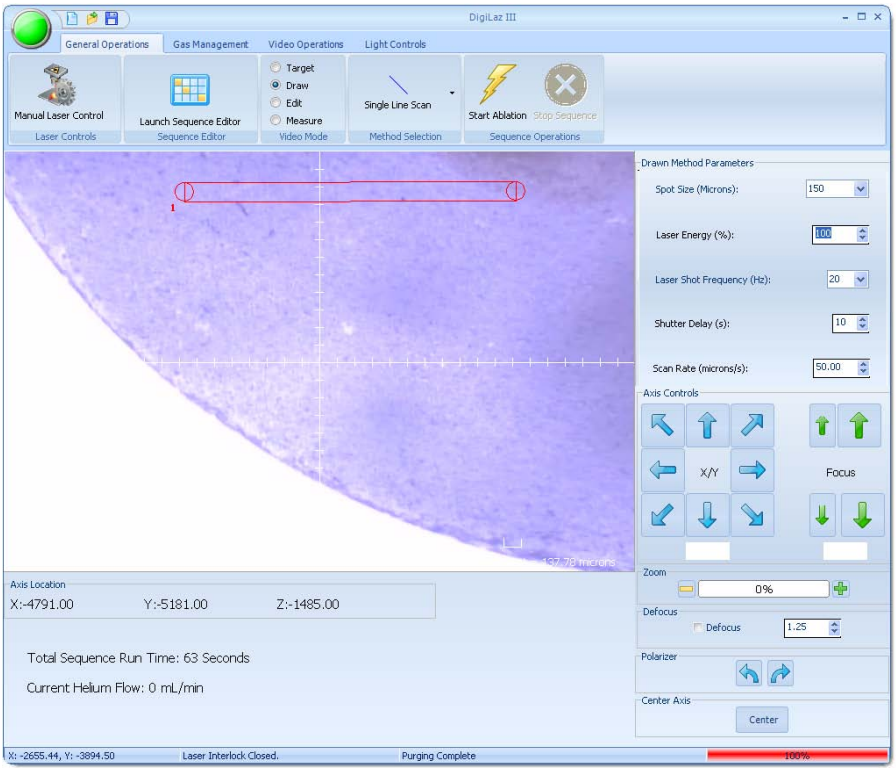


2 Click anywhere on the sample image to set the start point.

3 Click again to set the end point.

Multiple repetitions of the line scan, delay between scans and gas blank can all be set in the sequence editor to allow optimal integration with ICP software.

Example



Segmented Line Scan

Description

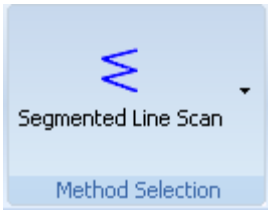
Segmented line scan allows the laser to follow features, such as the curve of an otolith or any other irregular feature. Each segmented line consists of a number of points which can all be edited.

Parameters

Energy, shot frequency, and spot size can all be set. The scan rate, expressed in µm/sec, automatically calculates the time per scan and the distance travelled.

How to Draw

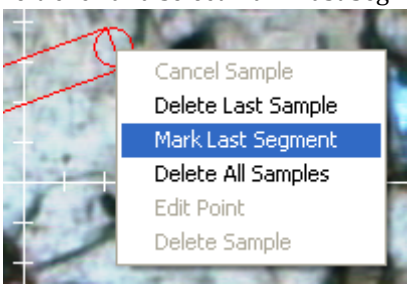
1 Select the Segmented Line Scan method.



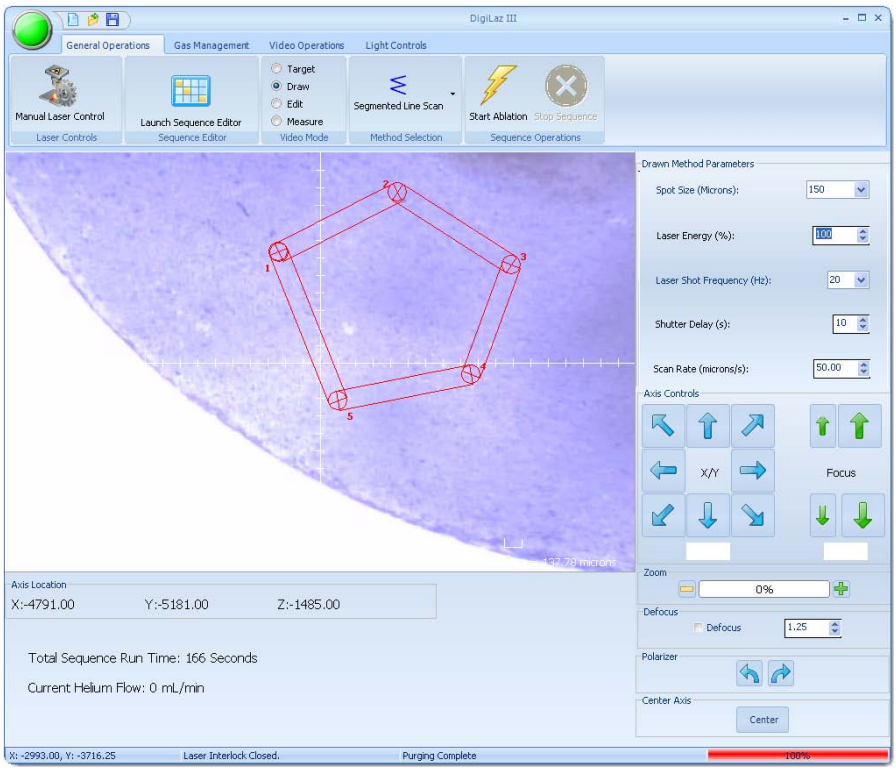
2 Click anywhere on the sample image to set the start point.

3 Click again to end a segment and begin the next one.

4 Left-click and select Mark Last Segment to set the end point.



Example



Line Raster

Description

In the line raster, the laser follows a line of discreet spots. By drawing a line on the sample image to indicate the area of interest, the software automatically calculates the number of spots which will fit on the space provided, given the spot size and distance between spots.

Parameters

The user enters the number of shots per spot and the spot size just as in the spot analysis, but this method allows the distance between spots to determine the method pattern. Energy and shot frequency may also be set. The number of spots and time of analysis are automatically calculated.

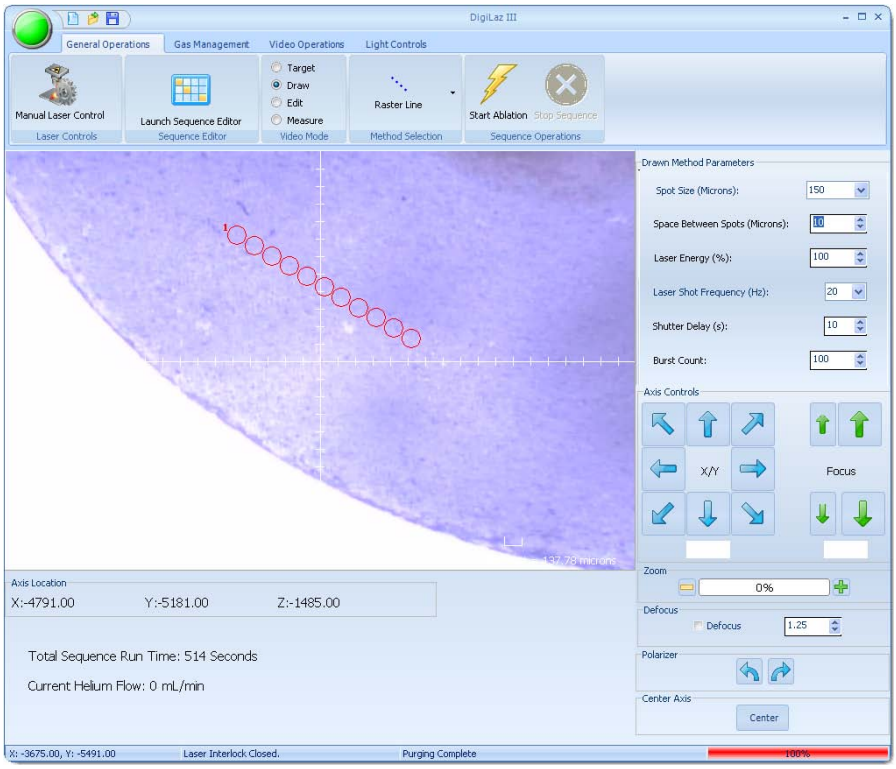
How to Draw

1. Select the Raster Line method.

2. Click anywhere on the sample image to set the start point.

3. Click again to set the end point.

Example



Scanning

Description

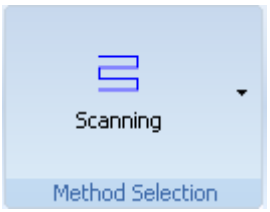
Here, the user defines an area using the mouse. This area is then divided up automatically given the distance between lines and the spot size.

Parameters

Energy, shot frequency, and spot size may be set. The number of lines, distances, and time of analysis depend on the area defined with the mouse and scan speed selected. This scan can be repeated if selected with delays and blanks to synchronize samples with the ICP sampling protocol.

How to Draw

1 Select the Scanning method.

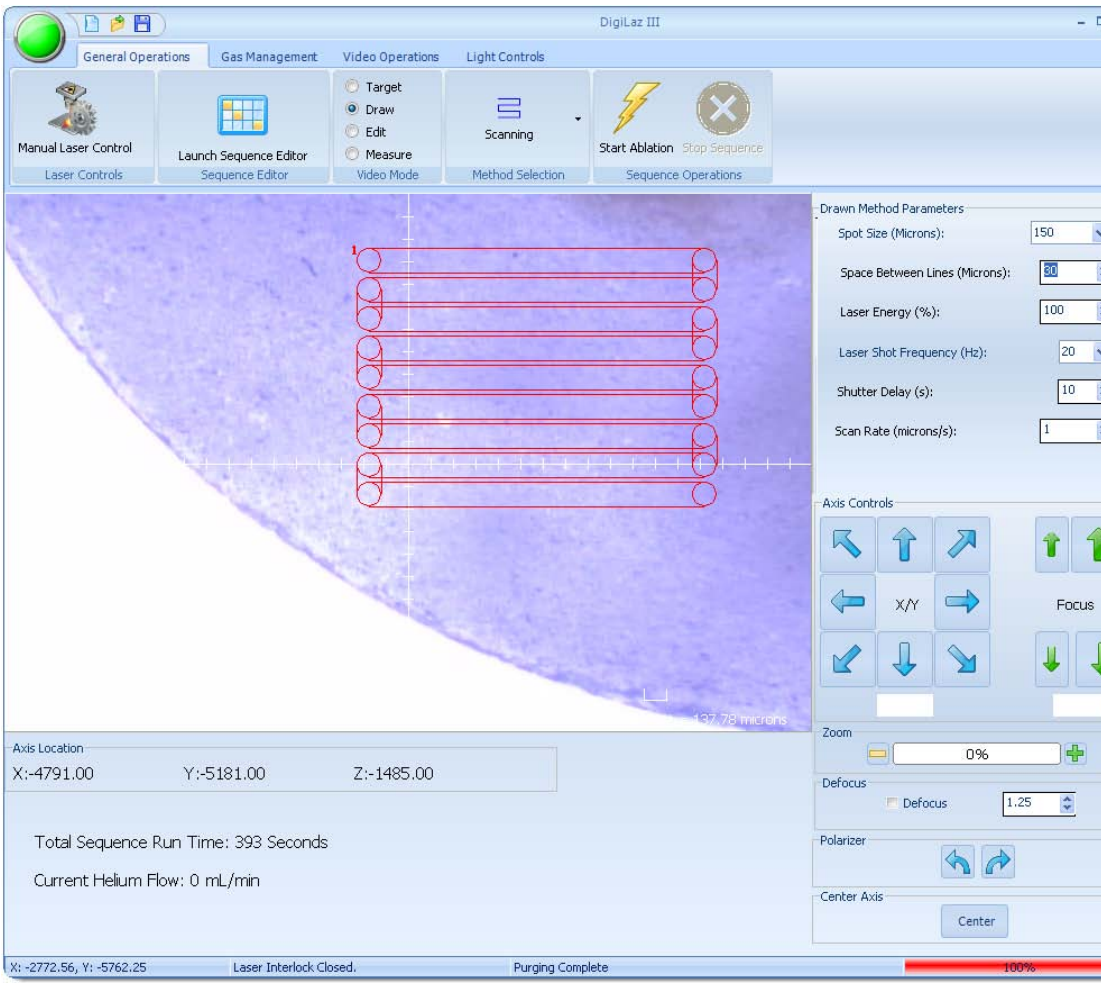


2 Set the method parameters.

3 Click anywhere on the sample image to set the start point.

4 Click again to set the end point.

Example



Area Raster

Description

Area raster is analogous to line raster except it covers a defined area in the same way that the area scan does.

Parameters

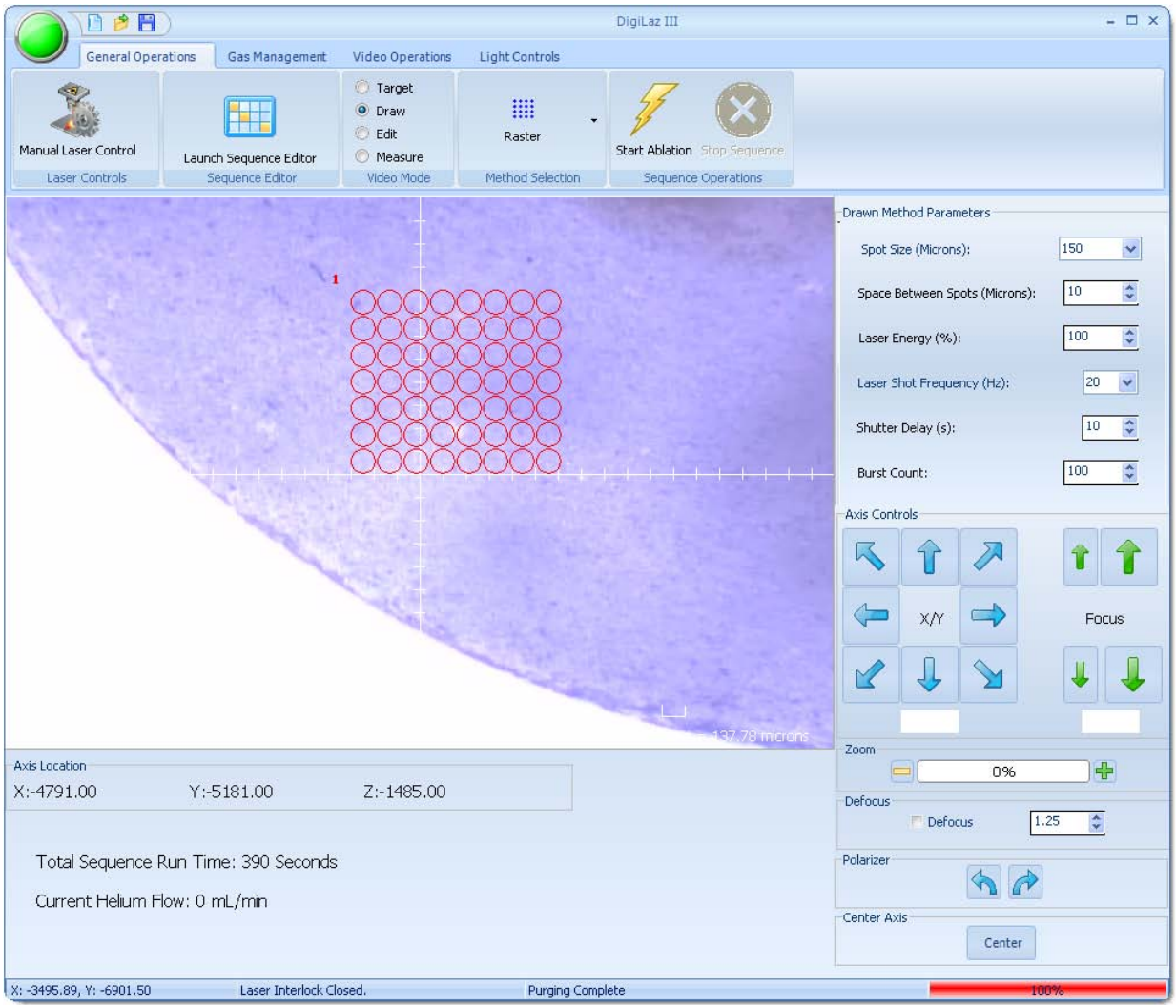
Enter the spot size and distance between spots. Energy, shot frequency, and number of shots per spot may also be set. The number of spots, total area, and time of analysis are automatically calculated.

How to Draw

1. Select the Raster method.

2. Set the method parameters.
3. Click anywhere on the sample image to set the start point.
4. Click again to set the end point.

Example


DigiLaz III
General Operations
Gas Management
Video Operations
Light Controls
Manual Laser Control
Laser Controls
Launch Sequence Editor
Sequence Editor
Target
Draw
Edit
Measure
Video Mode
Raster
Method Selection
Start Ablation
Stop Sequence
Sequence Operations
Drawn Method Parameters
Spot Size (Microns): 150
Space Between Spots (Microns): 10
Laser Energy (%): 100
Laser Shot Frequency (Hz): 20
Shutter Delay (s): 10
Burst Count: 100
Axis Controls
X/Y
Focus
Zoom
0%
Defocus
Defocus
1.25
Polarizer
Center Axis
Center
Axis Location
X:-4791.00
Y:-5181.00
Z:-1485.00
Total Sequence Run Time: 390 Seconds
Current Helium Flow: 0 mL/min
X: -3495.89, Y: -6901.50
Laser Interlock Closed.
Purging Complete
100%

Depth Profiling

Depth profiling is a method which moves the Z stage at specific increments and times to compensate for the "drilling" effect of the laser into the sample.

Normally, continuously ablating a single spot will result in the laser getting out of focus as the hole gets deeper. Depth profiling compensates for this by moving the Z stage up a user-defined number of steps to keep the laser in focus with the base of the crater.

If one uses depth profiling to determine changes in elemental composition with depth, analyzing a coating for instance, various steps with different parameters can be set to compensate for changes in the ablation characteristics of the layer. When a standard of known coating thickness is used, one can determine how many laser shots correspond to a given depth and from there use elemental signals to determine the depths of coatings. Up to 10 Steps can be used and the Z-rate and time are variable for each step. For most applications, 1 step is sufficient since the Z rate should be constant, however multiple steps are provided to give maximum flexibility for this method. As usual, spot size, energy and shot frequency are set up in the method which, as for others, can be saved and recalled.

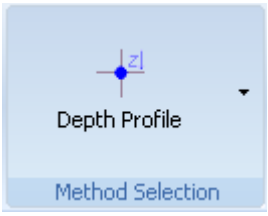
Parameters

The drawn method parameters are similar to the Single Point method: spot size, laser energy, shot frequency, and shutter delay. There is no burst count, since each shot is individually set up in the depth profile.

Additional parameters in the sequence editor are: Z-travel, time, and post-step delay. The Z-rate is automatically calculated by dividing the Z-travel by the time.

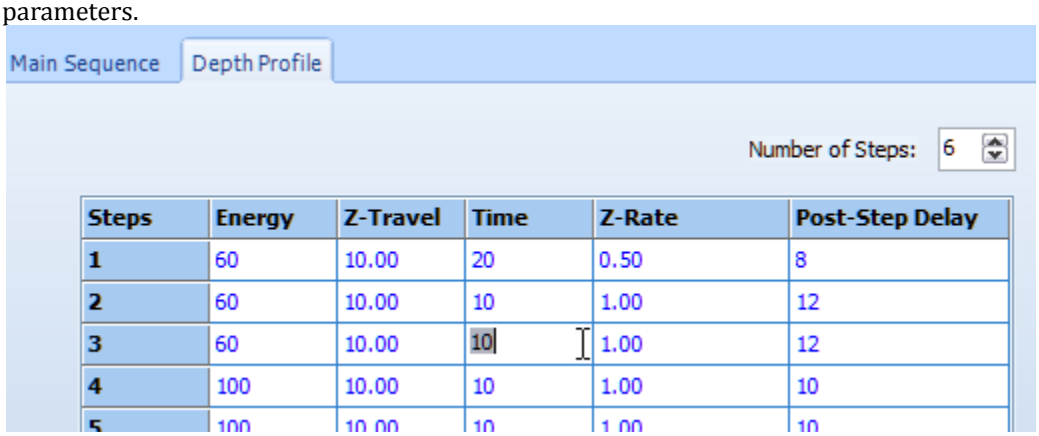
How to Draw

1. Select the Depth Profile method.



2. Set the drawn method parameters in the main window.

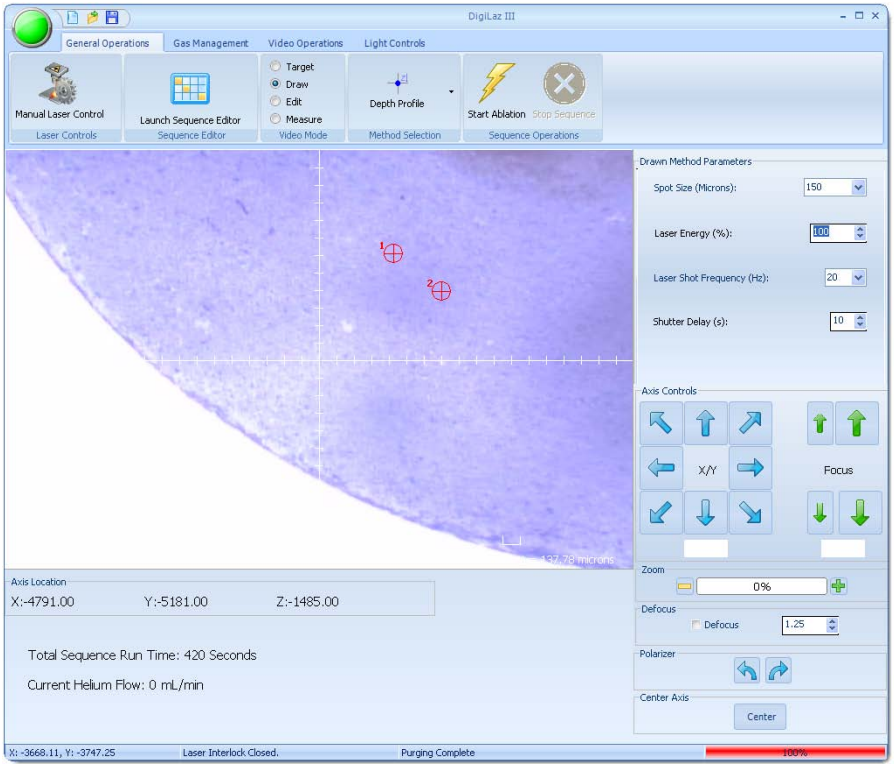
3 Open the Sequence Editor and select the Depth Profiling tab to set the per-step parameters.



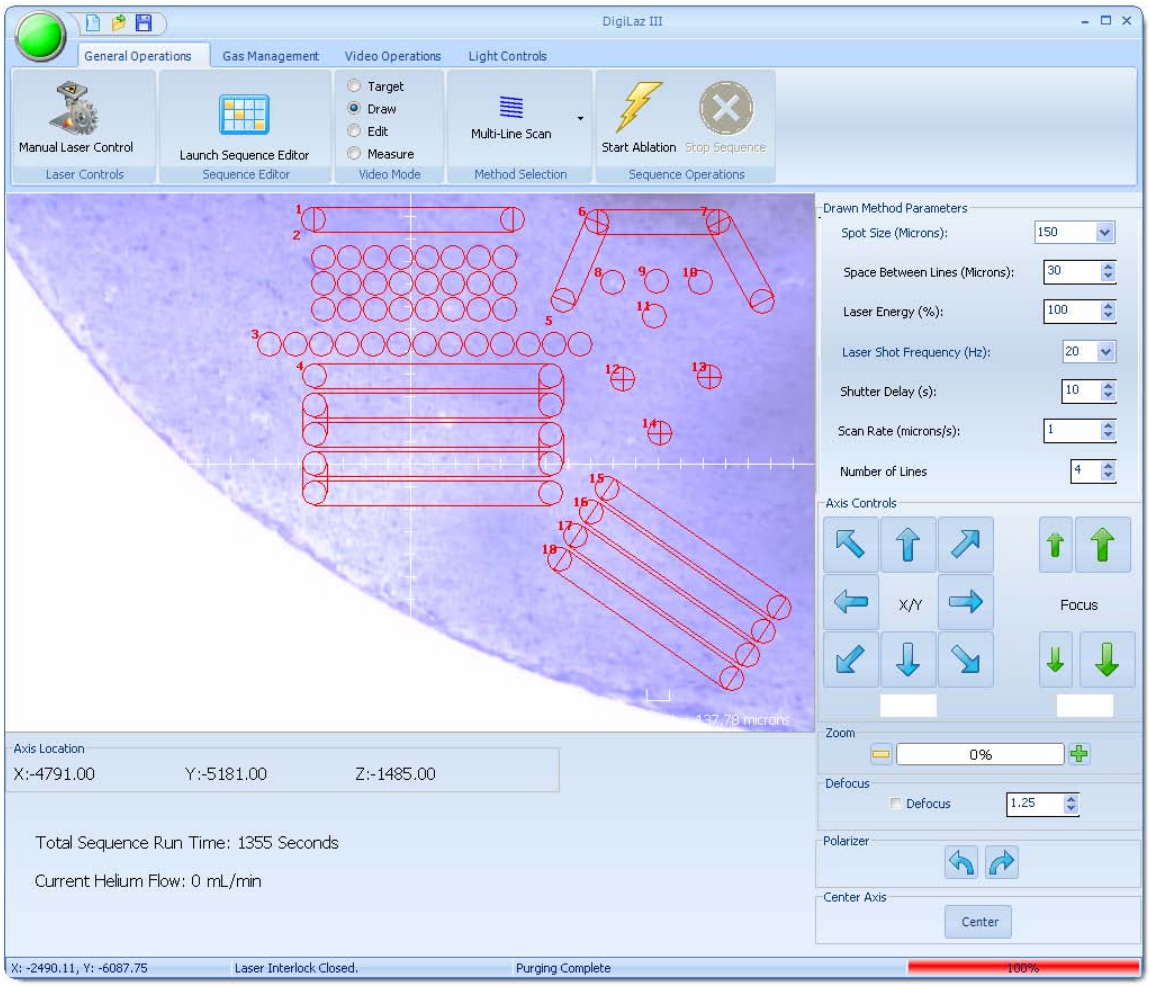
Steps	Energy	Z-Travel	Time	Z-Rate	Post-Step Delay
1	60	10.00	20	0.50	8
2	60	10.00	10	1.00	12
3	60	10.00	10	1.00	12
4	100	10.00	10	1.00	10
5	100	10.00	10	1.00	10

4 Click anywhere on the sample image to set the location.

Example

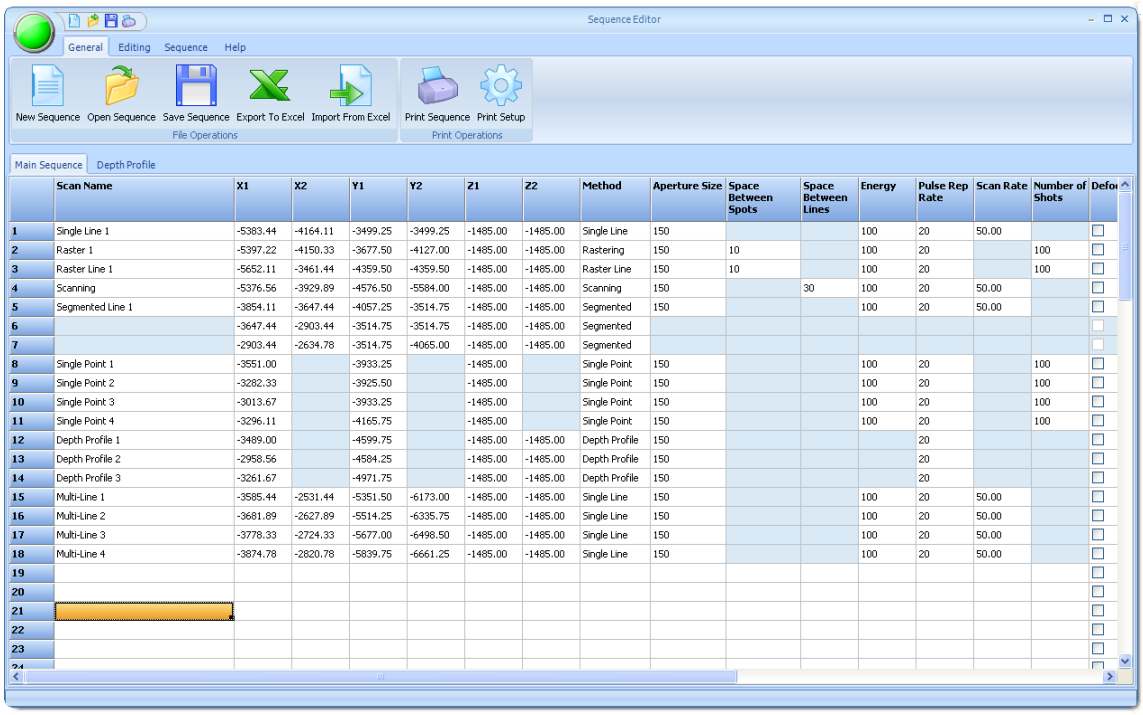


Multiple Method Drawing



DigiLaz III allows a number of different methods to be combined into a sequence. As shown above, all eight methods can be drawn on the sample image simultaneously and ablated in order. Parameters can be changed for the drawn methods at any time using the sequence editor.

Sequence Editor



	Scan Name	X1	X2	Y1	Y2	Z1	Z2	Method	Aperture Size	Space Between Spots	Space Between Lines	Energy	Pulse Rep Rate	Scan Rate	Number of Shots	Defo
1	Single Line 1	-5383.44	-4164.11	-3499.25	-3499.25	-1485.00	-1485.00	Single Line	150			100	20	50.00		
2	Raster 1	-5397.22	-4150.33	-3677.50	-4127.00	-1485.00	-1485.00	Rastering	150	10		100	20		100	
3	Raster Line 1	-5652.11	-3461.44	-4359.50	-4359.50	-1485.00	-1485.00	Raster Line	150	10		100	20		100	
4	Scanning	-5376.56	-3929.89	-4576.50	-5584.00	-1485.00	-1485.00	Scanning	150		30	100	20	50.00		
5	Segmented Line 1	-3854.11	-3647.44	-4057.25	-3514.75	-1485.00	-1485.00	Segmented	150			100	20	50.00		
6		-3647.44	-2903.44	-3514.75	-3514.75	-1485.00	-1485.00	Segmented								
7		-2903.44	-2634.78	-3514.75	-4065.00	-1485.00	-1485.00	Segmented								
8	Single Point 1	-3551.00		-3933.25		-1485.00		Single Point	150			100	20		100	
9	Single Point 2	-3282.33		-3925.50		-1485.00		Single Point	150			100	20		100	
10	Single Point 3	-3013.67		-3933.25		-1485.00		Single Point	150			100	20		100	
11	Single Point 4	-3296.11		-4165.75		-1485.00		Single Point	150			100	20		100	
12	Depth Profile 1	-3489.00		-4599.75		-1485.00	-1485.00	Depth Profile	150				20			
13	Depth Profile 2	-2958.56		-4584.25		-1485.00	-1485.00	Depth Profile	150				20			
14	Depth Profile 3	-3261.67		-4971.75		-1485.00	-1485.00	Depth Profile	150				20			
15	Multi-Line 1	-3585.44	-2531.44	-5351.50	-6173.00	-1485.00	-1485.00	Single Line	150			100	20	50.00		
16	Multi-Line 2	-3681.89	-2627.89	-5514.25	-6335.75	-1485.00	-1485.00	Single Line	150			100	20	50.00		
17	Multi-Line 3	-3778.33	-2724.33	-5677.00	-6498.50	-1485.00	-1485.00	Single Line	150			100	20	50.00		
18	Multi-Line 4	-3874.78	-2820.78	-5839.75	-6661.25	-1485.00	-1485.00	Single Line	150			100	20	50.00		
19																
20																
21																
22																
23																

All drawn method graphic coordinates and associated parameters are automatically stored in the sequence editor. All method parameters can be changed at any time. The "Run Sequence" button can be used to run all methods or individual rows can be highlighted to run select methods from the sequence.

5 Maintaining the Laser Ablation System

Routine maintenance of the LSX-213 Laser Ablation System consists of verifying safety systems performance and maintaining the cooling system. Additional periodic maintenance tasks are required, including replacement of the following laser ablation system components:

- Coolant
- Coolant de-ionizer cartridge
- Tubing Replacement
- Sample Cell Window

This manual explains how to verify safety systems performance, maintain the cooling system, replace the tubing and sample illumination lamp, and nitrogen purge the laser head.

Safety Systems/Maintenance Schedule

The LSX-213 Laser Ablation System is designed, as a Class 1 laser product, to contain all hazardous laser radiation during normal operation, as required by the U.S. Department of Health and Human Services. Normal operation of the LSX-213 shall not be allowed unless all safety systems are operational.

Periodic safety systems inspection and performance testing are mandatory to insure continuous laser radiation containment. Verify the operation of all safety systems, at least semi-annually, or whenever the LSX-213 has, or may have been transported, subjected to damage, or any other adverse conditions that could have affected safety systems' operation.

Safety System Inspection

WARNING

Before proceeding, read all of the safety notices (see "Safety and Regulatory Information" on page 87). Tampering with or deactivating safety systems and/or interlocks may result in personal injury.

1. Verify that removing the remote interlock connector disables the laser power supply.

   The remote interlock connector is located within the laser power supply communication cable on the back panel of the laser module, connected to the laser power supply port (Figure 5-1). Replace any malfunctioning components.

2. Verify that the laser will operate only with the laser power keyswitch in the ON position.

   Verify that the key can be removed only when the keyswitch is in the OFF position. Return the laser control unit for factory service if it malfunctions.

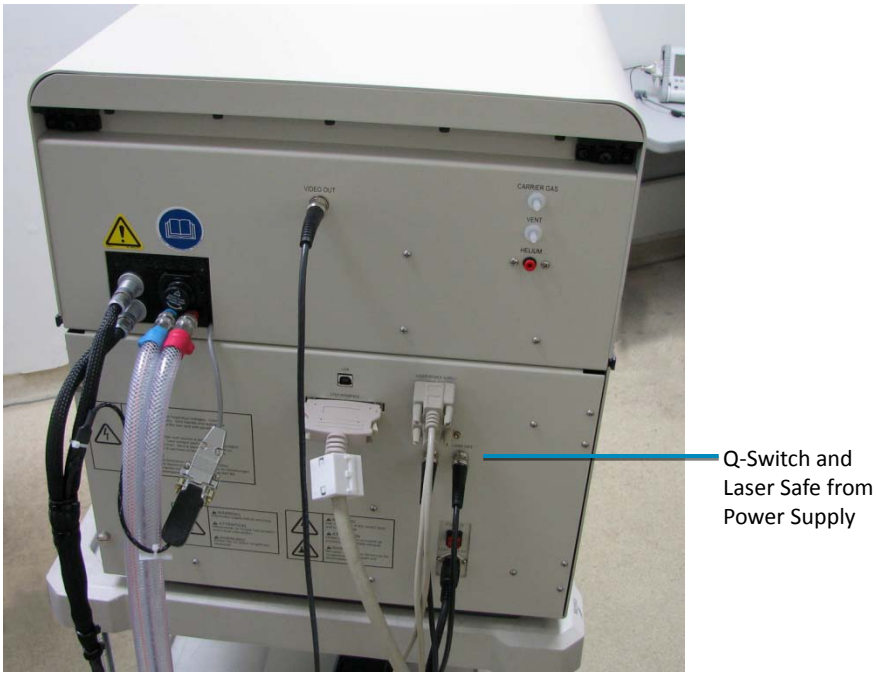


Figure 5-1 Rear View of the LSX-213

Cooling System Maintenance

Changing the laser cooling system coolant is the primary maintenance tasks that will be performed. Other items should also be checked periodically to maintain the cooling system properly. In addition, the cooling system has to be drained before transportation. The cooling unit reservoir must only be filled with distilled water. Do not use high purity lab grade de-ionized water since it can be corrosive.

Periodic Checks of the Cooling System

1. Circulate coolant through the system for at least 30 minutes every month when the laser is not in use.

   Turning the laser power supply keyswitch ON will turn on the coolant pump motor, and circulate the coolant.

2. Inspect the coolant level in the reservoir every week.

   Check to see that the coolant level visible in the reservoir is above the depression. When coolant is above the minimum level, the reservoir backlights are on continuously, indicating that the enough distilled water is present for normal operation. If the back light is not on, follow the steps below to fill the reservoir to proper levels.

Filling and Draining the Power Supply

Before shipping the laser, a CETAC Technologies technician drains the coolant from the coolant reservoir. In order to use the Cooling Group Unit, the customer must fill the coolant reservoir with about 1.5 liters of distilled water. Please follow the steps below:

1. Fill the bottle with coolant. Attach the coolant fill/drain connectors to the fill bottle. The hose with the single fitting connected to it attaches to the upper vent fitting. Loosen the cap on the fill bottle and add coolant until it drains from the vent fitting.

2. Turn the key switch to the ON ("I") position.

3. The pump will turn on automatically after the system is on and coolant will begin filling the umbilical coolant lines. When the coolant level falls below the depression in the front of the reservoir, the pump will shut off and the backlights in the reservoir will blink. Continue to add coolant until the umbilical coolant lines are full and the coolant level visible in the reservoir is above the depression. Disconnect the fill bottle and vent tube and, if using distilled water as a coolant, empty all remaining coolant from the fill bottle. When the coolant is above the minimum level, the reservoir backlights will remain on continuously.

4. To remove the coolant from the reservoir, connect the vent tube to the vent fitting, and then connect the empty bottle to the fill/drain fitting. Loosen the cap on the bottle and lower the bottle below the ICE450 as far as it can go. Lowering the bottle will cause the coolant to drain from the system. This is adequate to remove most of the coolant from the system. However, if water is the primary coolant used, this is not sufficient to prepare the ICE450 for shipment when freezing conditions are present. See the next step (5) for instructions on how to ship the unit in freezing conditions.

5. For a water-cooled (as compared to an ethylene glycol/water solution) system that is being prepared for shipment, it is necessary to remove **ALL** water from the system because there are places within the ICE450 where water becomes trapped and irreversible damage occurs to the internal components when the water freezes.

Disconnect the umbilical coolant lines from the ICE450 and drain the water from the reservoir (follow the steps described in Step 4). Then, disconnect the umbilical coolant lines from the laser head and reconnect the red fitting to the ICE450. Remove the vent fitting from the front of the reservoir and gently (do not use air pressure greater than 0.35 bar [5 psi]) blow air into the corresponding red fitting at the laser head end of the umbilical coolant lines. To prevent possible organic contamination of the coolant loop, do not blow by mouth into the tube. Continue to blow air until no more water is visible through the drain tube. Then disconnect the red fitting from the ICE450, connect the blue fitting, and repeat this process. Next, disconnect the blue fitting. Finally, reconnect the vent tube to the vent fitting on the reservoir, and tip the ICE450 forward to cause the water to run to the front. Following this detailed procedure will drain all the water from the system, and prevent freezing damage during shipment.

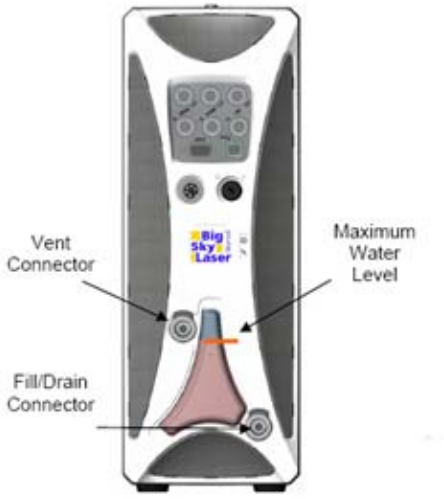


Figure 5-2 Fill/Drain port locations

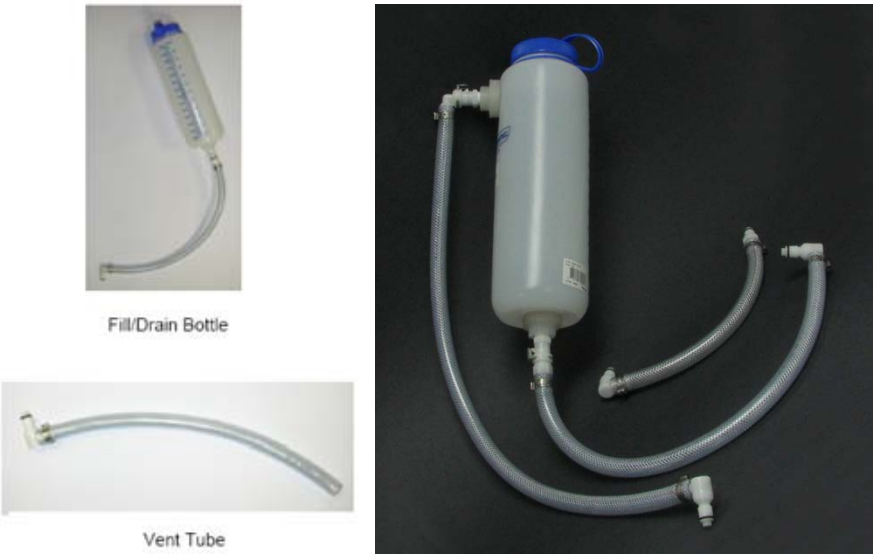


Figure 5-3 Fill/Drain Bottle and Vent Tube (old and new styles)

De-Ionizing Cartridge Maintenance (Inline Filter)

The ICE450 cooler/power supply can provide years of reliable performance given proper handling and some minor routine maintenance. Visually inspect your ICE450 monthly for coolant leaks, abnormal noises or damage to connectors and coolant ports. The de-ionization cartridge and coolant must be changed every six months just as you would regularly change the oil filter and oil in your car. Follow this procedure to change the deionized water:

Warning	**Before proceeding, switch the Power Supply OFF ("0") andunplug the AC power cord.**

1. Drain the coolant from the system. (It is recommended to change the coolant when changing the filter.)
2. Orient the ICE450 so that the rear of the unit is visible.
3. Press back the gray fittings and remove the hoses from the filter.

Figure 5-4 Inline Coolant Filter

4. Press the hoses into the new filter.
5. Re-fill the power supply with distilled water:

   a) Fill the bottle with fresh coolant. Attach coolant fill/drain connectors. The fill bottle connects to the fill/drain fitting and the fitting with a hose attaches to the upper vent fitting. Loosen the cap on the fill bottle, raise the bottle, and wait until the coolant drains from the vent fitting.

   b) Turn the key switch ON ("I"). The pump will turn on automatically after power-up, and begin filling the umbilical coolant lines. When the coolant level falls below the depression in the middle front of the reservoir, the pump will shut off and the reservoir lights will begin blinking. Continue to add coolant until the umbilical coolant lines are full and the coolant level visible in the reservoir is above the depression. Disconnect the fill bottle and vent tube, and if using water as a coolant, empty all remaining coolant from the fill bottle. When the coolant is above the minimum level, the reservoir lights will remain on.

De-Ionizing Cartridge Maintenance (Internal Filter)

The ICE450 cooler/power supply can provide years of reliable performance given proper handling and some minor routine maintenance. Visually inspect your ICE450 monthly for coolant leaks, abnormal noises or damage to connectors and coolant ports. The de-ionization cartridge and coolant must be changed every six months just as you would regularly change the oil filter and oil in your car. Follow this procedure to change the deionized water:

Warning	**Before proceeding, switch the Power Supply OFF ("0") andunplug the AC power cord.**

1 Orient the ICE450 so that the rear of the unit is visible.

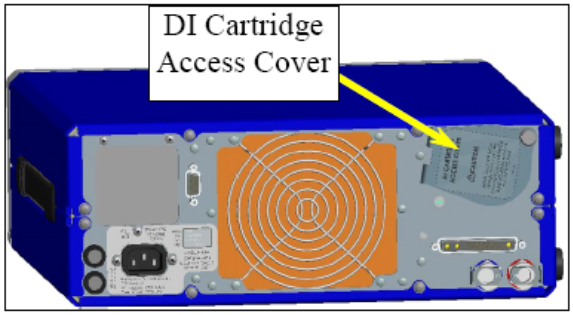


Figure 5-5 Location of the DI Cartridge Access Cover

2 As indicated on the DI cartridge access cover (Figure 5-5), it is necessary to drain the coolant from the ICE450. Follow the procedure described below:

To remove the coolant from the reservoir, connect the vent tube to the vent fitting, then connect the empty bottle to the fill/drain fitting. Loosen the cap on the bottle and lower the bottle below the ICE450 as far as it can go. This will cause the coolant to drain from the system. This is adequate to remove most of the coolant from the system, but is not sufficient to prepare the ICE450 for deionized cartridge exchange.

It is necessary to drain ALL water from the system. Disconnect the umbilical coolant lines from the ICE450 and drain the water from the laser head (follow the steps described above - "Filling and Draining the Power Supply"section). Disconnect the umbilical coolant lines from the laser head and reconnect the red fitting to the ICE450.

Remove the vent fitting from the front of the reservoir and gently (do not use air pressure greater than 0.35 bar [5 psi]) blow air into the corresponding red fitting at the laser head end of the umbilical coolant lines. Continue to blow air until no more water is visible flowing through the drain tube into the bottom of the bottle. Next, disconnect the red fitting from the ICE450, connect the blue fitting, and repeat this process.

Disconnect the blue fitting. Finally, reconnect the vent tube to the vent fitting on the reservoir, and tip the ICE450 forward to cause the water to run to the front.

3 Loosen the screw holding the DI cartridge access cover in place. The cover will then swing open 90 degrees. After opening the cover 90 degrees, remove it from the back of the ICE450 by pulling it away from the rear of the unit.

4 Grasp the end of the latch as indicated in Figure 5-6. Pull the latch to open it. It should open about 80 degrees before stopping.

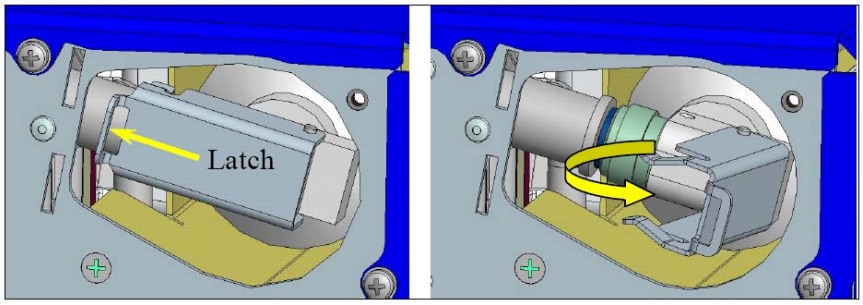


Figure 5-6 Latch Opening Procedure

5 By continuing to press on the lever, the DI cartridge connecting tube will release from the mating fitting. It is only necessary to move the DI cartridge about 6mm (¼") to be completely free of the mating connector. See Figure 5-6 for component positions.

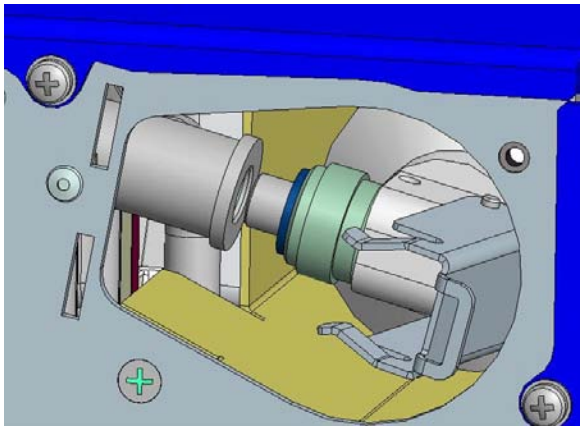


Figure 5-7 DI Cartridge Free of Mating Connector

6 Pull on the latch to extract the DI cartridge assembly through the opening in the back of the ICE450, as shown in Figure 5-8.

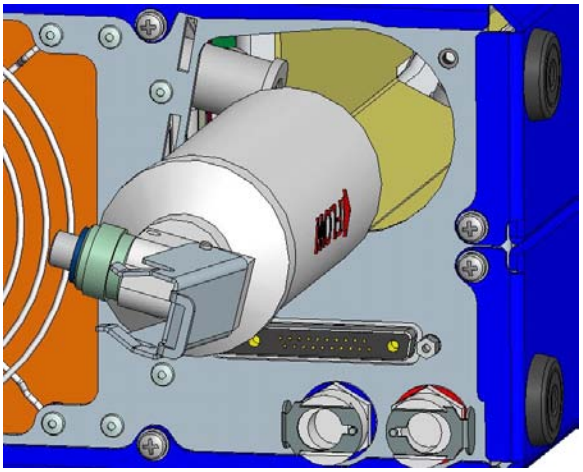


Figure 5-8 DI Cartridge Extraction

7 Orient the extracted DI cartridge assembly, and the new DI cartridge, as indicated in Figure 5-9. Note the direction of the FLOW arrow on the side of the cartridges. Unscrew the tube adapter fitting from the old cartridge and wrap the fitting threads with 3-4 turns of Teflon pipe-sealing tape. Thread the tube adapter fitting completely into the output (note FLOW arrow) end of the replacement DI cartridge, until the nut stops against the DI plastic body.

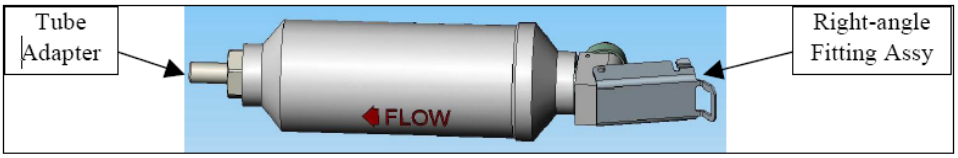


Figure 5-9 Tube Adapter and Right-Angle Fitting Assembly Locations

8 Unscrew the right-angle fitting assembly from the old cartridge and wrap the fitting threads with 3-4 turns of Teflon pipe-sealing tape. Thread the right angle fitting assembly completely into the open end of the new DI cartridge.

9 Insert the new DI cartridge assembly into the back of the Power Supply. The tube adapter fitting will engage another fitting deep inside the Power Supply, and may require a little force to insert. It is sometimes useful to rotate the cartridge slightly while pushing. After insertion, it should appear as shown in Figure 5-10.

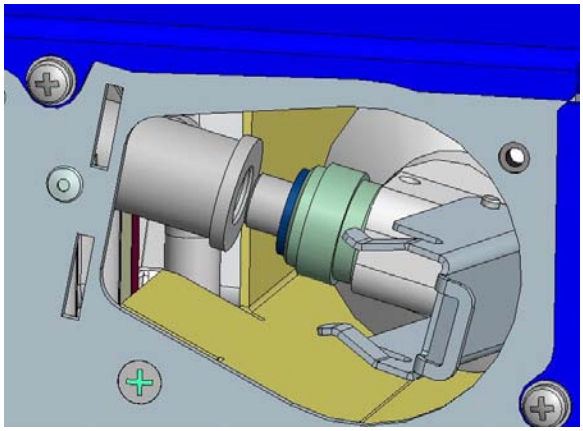


Figure 5-10 Re-Insertion of the DI Cartridge

10 Pull the cartridge back out slightly with the latch until the metal tube and the right-angle fitting lines up with the internal mating fitting. Use the latch to push the metal tube into the internal mating fitting, as shown in Figure 5-11.

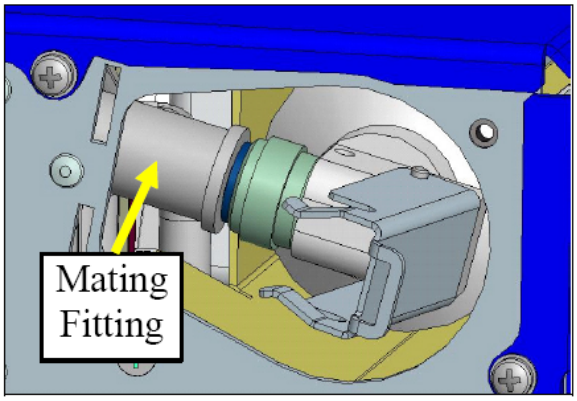


Figure 5-11 Insertion into the Internal Mating Fitting

11 While holding the two fittings together as described in Figure 5-11, push the latch into position, so that the metal tabs latch over the internal mating fitting, as shown in Figure 5-12.

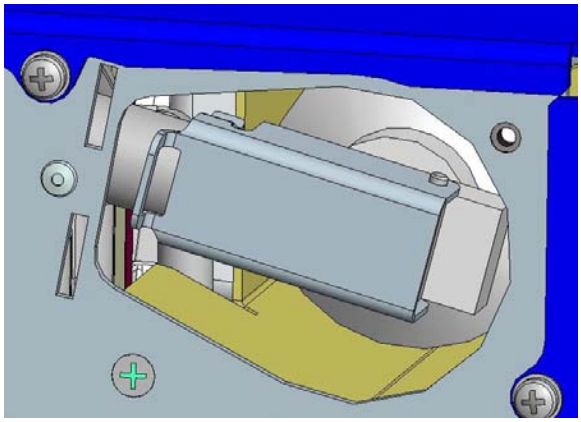


Figure 5-12 DI Cartridge Complete Assembly

12 Replace the access cover over the DI cartridge assembly.

13 Re-fill the Power Supply with distilled water following the fill procedure described below:

c) Fill the bottle with fresh coolant. Attach coolant fill/drain connectors. The fill bottle connects to the fill/drain fitting and the fitting with a hose attaches to the upper vent fitting. Loosen the cap on the fill bottle, raise the bottle, and wait until the coolant drains from the vent fitting.

d) Turn the key switch ON ("I"). The pump will turn on automatically after power-up, and begin filling the umbilical coolant lines. When the coolant level falls below the depression in the middle front of the reservoir, the pump will shut off and the reservoir lights will begin blinking. Continue to add coolant until the umbilical coolant lines are full and the coolant level visible in the reservoir is above the depression. Disconnect the fill bottle and vent tube, and if using water as a coolant, empty all remaining coolant from the fill bottle. When the coolant is above the minimum level, the reservoir lights will remain on.

Internal Tubing Replacement

In the event the sample gas/valve assembly tubing becomes contaminated, it must be replaced. A spare parts kit can be obtained from CETAC. In lieu of purchasing the kit, the tubing can be changed with stock Tygon tubing. All the Tygon tubing is 1/4" O.D. and 1/8" I.D.

Symptoms that the tubing needs to be replaced can include the following:

- Argon blank contamination
- Poor stability and poor long-term precision
- Visible coating of ablated material in the transfer line

WARNING

PINCH HAZARD
Fingers could be pinched between the top cover and the main cabinet. Use caution when opening and closing the top cover.

When changing the tubing, care must be taken when disconnecting it from the nuts on the internal valves. There are two ferrules that provide the sealing pressure. Loss of the ferrules may cause leakage in the tubing assembly. After changing the tubing, check the plasma for flicker or contraction, second, open and shut the front door. This will cause the valves to cycle, any air leaks caused by improperly fitted tubing may cause the plasma to extinguish.

6 Troubleshooting the Laser Ablation System

In the event that the product does not function properly, isolate the problem to determine if it originates in the host computer, the analytical instrument, or the laser ablation system.

The laser controller has been designed to control the laser, and warn the user of problems if they occur. The microprocessor-based system monitors the laser ablation system, and automatically shuts down the laser if a fault occurs. Software limits have been factory selected to protect the laser system against electrical and optical damage.

If you determine the problem is in the LSX-213, check the AC power transformer, the communications interface, the safety interlocks, or the laser head to find the cause of the problem and resolve it.

This chapter explains how to troubleshoot minor LSX-213 problems. If you cannot solve a problem using the steps given in this chapter, contact CETAC Technologies Customer Service and Support (1-800-369-2822) or an authorized service representative.

NOTE:

This chapter explains how to troubleshoot LSX-213 problems. This manual will guide a service engineer, technician or authorized operator to find where the LSX-213 has failed. If you cannot solve a problem using the steps given in this chapter, contact CETAC Technologies Customer Service and Support (1-800-369-2822) or an authorized service representative.

When the laser ablation system does not function properly, first isolate the problem to determine if it originates in the analytical instrument (ICP), the computer, or the laser ablation system.

If you determine the problem is in the LSX-213, start by checking the AC power, power transformer, the communications and control interfaces, the safety interlocks, and the laser head.

Power System Problems

A possible cause of LSX-213 malfunction is a problem in the power system. If the laser ablation system is not responding, power may not be getting to the LSX-213 or it may not be getting to the power supply/chiller. If this is the case, the READY indicator (green LED) on the front of the laser module is off and all of the LEDs on the front of the power supply are off. To troubleshoot this problem, complete the following steps:

WARNING

DANGER - HIGH VOLTAGE. The Laser power supply/chiller contains lethal current and voltage levels. Do not attempt any service beyond described troubleshooting procedures.

1. Check the Transformer indicator light: Power is supplied to the Laser system via a 100V-240V AC in, 26 VDC out transformer. The light on the power transformer shoud be green if the transformer is functioning properly. Follow the cord from the transformer to the rear of the Laser case and check for good connections. If the light on the transformer is not glowing green, the transformer may be faulty. If it is green and has a firm connection, cycle the red on/off switch on the back of the laser, the laser system "clicks" when power is supplied.

2. Check that the AC line cord on the laser power supply/chiller is connected to the AC outlet, and the AC power switch is turned on.

   Connect the cord if it is not already plugged in to the AC outlet, and turn the power switch on using the key switch. Normally, the pump of the chiller will start and the lights on the front will light when the key is turned. Make sure that the emergency off button is not engaged (the large red button on the front of the power supply/chiller) it should protrude about 1 cm. If not, turn it in the direction indicated by the arrows and it will pop out.

3. Check the wall outlet.

   The power supply may trip a GFI (ground fault interrupt) outlet in it's normal operation as it discharges internal capacitors. Make certain that the power supply/chiller unit is not plugged into a GFI outlet. If it is, move the

AC line cord to a standard outlet, or have a qualified electrician switch the AC power outlet from GFI to a standard, grounded outlet.

WARNING

Do not attempt to service the rear cabinet of the laser ablation system.

There are no user serviceable parts inside the rear electronics cabinet of the laser unit. The rear cabinet should not be opened except by an authorized service representative.

Fuses

The only fuses in the LSX-213 are in the laser power supply. The laser module has no replaceable fuses. The power supply/chiller has one fuse which can be checked in the event that it does not operate despite taking the actions outlined above. The fuse is accessed from the rear of the power supply and is held in place with a straight screwdriver cover. Check and replace if necessary. Contact CETAC Customer Service (1-800-369-2822) if there are any questions or if the unit requires factory service.

- Laser Power Supply 5A. Type 3AG "Slowblo"

WARNING

Replace fuses with specified type(s) and rating(s) only.
If the AC power is within specifications and the laser ablation system will not operate, call CETAC Customer Service and Support, or an authorized service representative.

Interface Problems

The control computer directs operation of the LSX-213. A malfunction of the laser ablation system can indicate a problem with the cables, or with the software configuration of the computer. The following sections explain how to troubleshoot these problems.

RS-232 Cable Problems

The first step in troubleshooting suspected interface problems is to check the RS-232 cable. To do so, complete the following steps:

1. Check the READY indicator (green LED) on the front of the laser module to ensure the power is on.
2. Check the RS-232 cable to ensure it is plugged in to the COMPUTER port of the laser module.

   If the cable is plugged in, ensure that the connector is properly oriented, fully seated, and the thumbscrews are fully and evenly tightened.
3. Check the host computer to ensure that the RS-232 cable is connected to the COM1 port or USB port if using the USB configuration.

   If the RS-232/USB cable is plugged in, ensure that it is tightened properly.

Stepper Interface Cable Problems

The first step in troubleshooting suspected interface problems is to check the large stepper interface cable. To do so, complete the following steps:

1. Check the READY indicator (green LED) on the front of the laser module to ensure the power is on.
2. Check the cable to ensure it is plugged in to its port on the laser module.

   If the cable is plugged in, ensure that the connector is properly oriented, and fully seated.
3. Check the host computer to ensure that the stepper cable is connected to the stepper control board.

   Since this is a large, 68 pin cable, take special precaution when seating the cable since it is possible to bend the pins on the cable or connectors if the cable is forced. When replacing the cable, inspect the plug for any bent pins.

Software Configuration Problems

If the cables are connected properly and the laser ablation system is still not communicating with the control computer, ensure that the software is configured correctly. To do so, complete the following steps:

1. Run the LSX-213 software, or the stepper control program, to ensure that the computer is functioning properly.

2 Check the software configuration for the correct COM port selection and communications parameters (9600, N, 8, 1).

If the laser ablation system is connected to a port other than the one defined, or the baud rate (9600), parity (N), number of data bits (8) or number of stop bits (1) selected is different, correct the configuration and save the changes.

If you are not sure which COM port the laser ablation system is physically connected to, you can easily test the computer by following the procedure for testing the communications interface.

Safety Interlock Problems

There are seven safety interlocks in the LSX-213 Laser Ablation System to protect personnel from accidental UV laser beam and high voltage exposure, and to protect the laser from overheating.

The laser module contains 2 interlocks to protect personnel from accidental UV laser beam exposure. If the top cover or the front door of the laser module is opened during laser firing, the system will shut down and prevent further operation until the faults are corrected.

WARNING **Do not deactivate any safety interlocks. Call CETAC Technologies Customer Service and Support if safety interlock-related problems occur.**

The laser controller contains four interlocks to protect personnel from high voltage exposure, and to protect the laser from overheating. If the laser controller cover is opened, or the remote interlock has a problem, the cooling system overheats, or the coolant flow is interrupted, the system will shut down and prevent further laser operation until the faults are corrected.

Laser module interlocks

Top cover. The laser module top cover interlock is located inside the upper compartment of the laser module. A switch opens whenever the spin lock is moved from the closed and locked position, ensuring that the laser cannot be operated with the laser module top cover opened.

Front door. The laser module front door interlock is located inside the lower compartment of the laser module. A switch opens whenever the front door is moved from the closed position, ensuring that the laser cannot be operated with the laser module front door opened.

Laser Controller Interlocks

Coolant flow. The coolant flow interlock ensures that coolant is flowing through the laser head. The coolant flow is monitored by a magnetic switch that is located in the coolant loop.

If a coolant flow fault occurs, the coolant flow has been stopped by an obstruction in the cooling loop or coolant hoses, or the circulating pump has stopped due to a pump motor failure or blown fuses.

To test, check for turbulence in the coolant reservoir. If the coolant in the reservoir is not moving, there is a blockage in the cooling loop that must be cleared; drain the cooling system as described in "Filling and Draining the Power Supply" on page 67.

If there are air bubbles in the coolant lines, there could be a coolant flow fault. A laser fault will appear on the power supply and a coolant fault will appear in the software. To correct the problem, turn the power supply key on for a few minutes and then turn it off. Repeat this a couple of times until no air bubbles exist. The fault indicators should disappear.

Remote Interlock. If the remote interlock connection is broken by a bad cable or a fault in the interlock loop, the laser cannot be operated.

Coolant temperature. The coolant temperature interlock ensures that the coolant temperature does not exceed an acceptable level. The coolant temperature sensor is located on the heat exchanger inside the cooling unit and will open if water temperature exceeds 150°F (65°C).

Laser Problems

A malfunction of the LSX-213 laser can indicate a problem with the laser electronics unit, laser-pumping energy, the cooling system, or with the laser flashlamp. The following sections explain how to troubleshoot these problems.

WARNING

DANGER - INVISIBLE LASER RADIATION. The LSX-213 uses a Class IV Nd:YAG Laser. The output beam is, by definition, a safety and fire hazard. Precautions must be taken during use and maintenance to prevent accidental exposure to direct or reflected radiation from the laser beam.

No Laser Output

No AC power, low laser pumping energy, or improperly connected control cables can result in no laser output. The laser will not operate if there is no coolant flow or the coolant temperature is too high. Make sure the coolant level is correct.

To further troubleshoot this problem, complete the following steps:

1. With the AC power off and the power cord unplugged, check all the electrical connections between the laser module and laser electronics unit.

   Make sure all connections are secure, that the cables are installed correctly, and not causing the system to malfunction.

   If the cables are connected correctly, continue troubleshooting with step 2.

WARNING

DANGER - HIGH VOLTAGE. Both the laser head and laser electronics unit contain electrical circuits operating at lethal voltage and current levels. Always unplug and wait at least one (1) minute to allow capacitors to bleed down before servicing any part of the laser system.

2. Operate with the manual laser controls.

The manual laser controls are accessible from the main software screen by pressing the Manual Laser Control button. With a familiar sample in the cell, set the spot size to 200µm, the energy to 100% and the shot frequency to 20 Hz. Set the firing mode to "burst" and set the burst count to 200. Press "Start Laser". These settings should produce a 200µm crater in 10 seconds (after the shutter delay) This will test the Q-switch, shutter and the laser itself independent of any methods.

3 Observe the results of the manual laser test.

If operating the manual controls test above gave anything other than the round crater expected, make a note of whether the power supply made the typical clicking sound, whether there was any mark on the test sample at all or if the crater was non-circular. Given this information, consult your CETAC service representative who will provide further guidance.

WARNING **Modification of the furnished laser power supply is done solely at the user's risk. Call CETAC Technologies Customer Service and Support if power system-related problems occur.**

Low Laser Efficiency

Laser output energy below nominal may suggest only gradual lamp and/or cooling system degradation. These characteristics are normal over time, and with large laser shot accumulations (>30 million). Contaminated coolant, a laser flashlamp that needs to be replaced, or a resonator in need of adjustment can all result in low laser efficiency.

To troubleshoot this problem, complete the following steps:

1 Inspect the coolant for contamination.

The coolant should be clear, and free from contaminants; there should not be any visible particulates or organic contaminants in the coolant. Black particulates are a sign of pump wear, and green or black slime is an indication of organic substances (algae) growing in the cooling system. The built in de-ionizer in the reservoir should be replaced if any contamination is evident in the system.

If the coolant, and cooling system, is not contaminated, continue troubleshooting with step 2.

NOTE:

If contaminated coolant is suspected, the cooling system must be completely purged and properly cleaned prior to operating the laser. Contact CETAC Technologies (1-800-369-2822) for instructions on how to clean your laser cooling system if you find organically contaminated coolant.

2 Check the laser flashlamp age.

The number of times that the flashlamp has been triggered can be displayed on the power supply pendant. If this number is in excess of 30 million, it is likely that the flashlamp intensity and corresponding laser output energy will be low.

3 Replace the Flashlamp.

For optimal performance, the flashlamp should be replaced approximately every 30 million shots. Replace the laser flashlamp if over 30 million shots. Contact CETAC Technologies (1-800-369-2822) for service on replacing the flashlamp

CAUTION Contact CETAC Technologies (1-800-369-2822) for any repair actions necessary beyond those described in this manual. Attempts to adjust, repair, or replace optics may cause additional problems and void warranties.

Carrier Gas System

The carrier gas is the medium that delivers the ablated sample to the ICP-MS. The carrier gas for the LSX-213 is helium and is controlled by the helium mass flow controller via computer. Argon from the host ICP is used as a make-up gas which is mixed downstream of the sample cell before exiting the sample out port on the LSX-213. If, for whatever reason, helium is not available or desired, the helium flow can be set to 0 in the control software which triggers argon from the ICP to take over as carrier gas. The helium mass flow controller provides feedback to the software so that if the value entered cannot be met, as would be the case if the helium tank was empty, an error will be displayed. The helium controller and valve assembly is a maintenance free system.

Laboratory grade helium is connected to the red push-connector in the rear of the Laser system with the supplied tubing (1/8" OD). To remove the tubing from the push-connector, push the red collar inward then pull the tubing outward.

Contamination

Cross contamination can occur if many different sample types are used. A complete tubing change may be required if the LSX-213 is being used continuously and with different samples. The operator must be aware of the background materials to prevent any cross-contamination from occurring.

Returning the Product to CETAC for Service

Refer to the following information if you need to return the product to CETAC Technologies for service.

Shipping the Product

Follow these guidelines when shipping the product:

- **Use the original packing materials.** If the original shipping materials are not available, place a generous amount of shock-absorbing material around the instrument and place it in a box that does not allow movement during shipping. Seal the box securely.
- Contact CETAC Technologies before shipping the product.
- Pre-pay all shipping expenses including adequate insurance.
- Write the following information on a tag and attach it to the product:
  - Name and address of the owner
  - Product model number and serial number
  - Description of service required or failure indications
- Mark the shipping container as FRAGILE.
- In all correspondence, refer to the instrument by model name or number and full serial number.
- **Do not return products which are contaminated by radioactive materials, infectious agents, or other materials constituting health hazards to CETAC employees.**

Product Warranty Statement

> **NOTE**
>
> Contact CETAC Technologies or refer to the warranty card which came with your product for the exact terms of your warranty. The following copy is provided for your convenience, but warranty terms may be different for your purchase or may have changed after this manual was published.

CETAC TECHNOLOGIES warrants instruments for (1) one year from the date of shipment. Any CETAC manufactured unit sold directly to the End-User found in reasonable judgment of CETAC to be defective in material or workmanship will be repaired by CETAC without charge for parts and labor. Only CETAC manufactured instruments are covered by the (1) one year warranty. For a complete listing of our Automation products please visit our web site at www.cetac.com and follow the Automation link.

The unit, including any defective part, must be returned to CETAC within the warranty period. The expense of returning the unit to CETAC for warranty service will be paid for by the buyer. CETAC's responsibility in respect to warranty claims is limited to making the required repairs or replacements, and no claim of breach of warranty shall be cause for cancellation or recession of the contract of sale of any unit.

Products may not be returned which are contaminated by radioactive materials, infectious agents or other materials constituting health hazards to CETAC employees.

This warranty does not cover any unit that has been subject to misuse, neglect, negligence or accident. The warranty does not apply to any damage to the unit that is the result of improper installation or maintenance, or to any unit that has been operated or maintained in any way contrary to the operating or maintenance instructions as specified in the CETAC Instruction and Operations Manual. The warranty does not cover any unit that has been altered or modified so as to change its intended use. Any attempt to repair or alter any CETAC unit by anyone other than by CETAC authorized personnel or agents will void this warranty.

In addition, the warranty does not extend to the repairs made necessary by the use of parts, accessories, or fluids which are either incompatible with the unit or adversely affect its operation, performance or durability.

CETAC reserves the right to change or improve the design of any unit without assuming any obligation to modify any unit previously manufactured.

THE FOREGOING EXPRESS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

CETAC'S OBLIGATION UNDER THIS WARRANTY IS STRICTLY AND EXCLUSIVELY LIMITED TO THE REPAIR OR REPLACEMENT OF DE-FECTIVE PARTS, AND CETAC DOES NOT ASSUME OR AUTHORIZE ANYONE TO ASSUME FOR THEM ANY OTHER OBLIGATION.

CETAC ASSUMES NO RESPONSIBILITY FOR INCIDENTAL CONSEQUENTIAL OR OTHER DAMAGES (EVEN IF ADVISED OF SUCH POSSIBILITY), INCLUDING BUT NOT LIMITED TO, LOSS OR DAMAGE OF PROPERTY, LOSS OF REVENUE, LOSS OF USE OF THE UNIT, LOSS OF TIME, OR INCONVENIENCE.

This warranty and all matters arising pursuant of it shall be governed by the laws of the State of Nebraska, United States.

Returned Product Procedures

Claims for shipment damage (evident or concealed) must be filed with the carrier by the buyer. CETAC must be notified within ninety (90) days of shipment of incorrect materials. No product may be returned, whether in warranty or out of warranty, without first obtaining approval from CETAC. No replacements will be provided, nor repairs made, for products returned without such approval. Any returned product must be accompanied by a return authorization number. The expense of returning the unit to CETAC for service will be paid by the buyer. The status of any product returned later than thirty (30) days after issuance of a return authorization number will be subject to review. Shipment of repaired products will generally be made forty-eight (48) hours after the receipt.

Do not return products which are contaminated by radioactive materials, infectious agents, or other materials constituting health hazards to CETAC employees.

Returned Product Warranty Determination

After CETAC's examination, warranty or out of warranty status will be determined. If a warranted defect exists, the product will be repaired at no charge and shipped prepaid back to the buyer. If the buyer desires an air freight return, the product will be shipped collect. Warranty repairs do not extend the original warranty period.

If an out of warranty defect exists, the buyer shall be notified of the repair cost. At such time the buyer must issue a valid purchase order to cover the cost of repair and freight, or authorize the products to be shipped back as is, at the buyer's expense. Failure to obtain a purchase order number approval within fifteen (15) days of notification will result in the products being returned as is, at the buyer's expense.

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7 Safety and Regulatory Information

Review this product and related documentation to familiarize with safety markings and instructions before you operate the instrument.

Characteristics

Environmental Characteristics

Operating Temperature	+10° C to +30° C (+50° F to +85° F)
Non-Operating Temperature	+0° C to +55° C (+32° to +131° F)
Operating Altitude	Up to 2,000 m (6,562 ft)
Relative Humidity	0% to 95% non-condensing
Pollution Degree	Pollution Degree 2 Normally no pollution or only dry, non-conductive pollution occurs. The pollution has no influence. Occasionally, however, a temporary conductivity caused by condensation may be expected.

Table 7-1: Environmental Characteristics

For indoor use only.

Avoid sudden, extreme temperature changes which could cause condensation on circuit boards in the product.Electrical Characteristics

Power requirements

Cooler/Power Supply	**Input:** AC Voltage, Frequency, and Current 100-250 V AC ± 10% ~ 47-63 Hz Installation Category: CAT II (Line voltage in appliance and to wall outlet) **Output:** 28 V DC, 4.6 A
LSX-213 Laser Ablation System	**Input:** DC Voltage and Current ⎓ 28 V 4.6 A Installation Category: CAT I (Mains isolated) Use only with the provided cooler/power supply.

Table 7-2: Power Requirements

Performance characteristics

Video resolution	680x484 pixels, 470 lines

See page 10 for laser characteristics.

Fuses

CAUTION Replace only with a fuse of the same type and current rating.

See page 77 for fuse replacement instructions and fuse ratings.

Safety Notices

WARNING **If the equipment is used in a manner not specified by CETAC Technologies, the protection provided the equipment may be impaired.**

Repair or service that this not covered in this manual should only be performed by qualified personnel.

Laser Safety

This instrument complies with appropriate safety standards. With specific regard to the laser, the equipment complies with laser product performance standards set by government agencies as a Class 1 laser product. It does not emit hazardous light; the beam is totally enclosed during all modes of customer operation and maintenance.

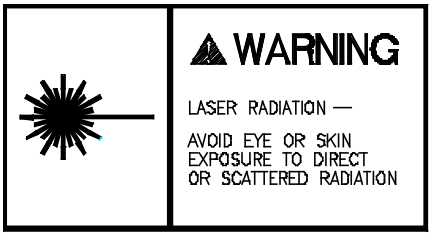
U.S. Regulations – Class 1 Laser Product

This instrument is certified to comply with laser product performance standards set by the U.S. Department of Health and Human Services as a Class 1 laser product.

This means that this is a class of laser product that does not emit hazardous laser radiation; this is possible only because the laser beam is totally enclosed during all modes of customer operation.

The laser produces a beam that, if looked into, could cause eye damage. Service procedures must be followed exactly as written without change.

The following warning is affixed to the front cover of the laser ablation system:



WARNING

EYE DAMAGE HAZARD
Because the internal laser beam may cause eye damage, do not open the cabinet. Wearing glasses and contact lenses, etc., increases the hazard. All maintenance is to be performed by an Authorized CETAC Service Provider.

WARNING

LASER INJURY HAZARD
Use of controls, adjustment or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

CDRH Laser Product Regulations

The Center for Devices and Radiological Health (CDRH) of the U.S. Food and Drug Administration implemented regulations for laser products on August 2, 1976. Compliance is mandatory for products marketed in the United States.

Coolant

The cooling system, located in the laser power supply, is filled with DISTILLED WATER. Do not fill with any other type of fluid.

The cooling system should contain a sufficient amount of distilled water. The fault light will come on if the coolant is in interlock mode.

Ventilation

The Laser Power supply cooling fan should remain unobstructed at all times. Do not operate the instrument if the cooling fan is blocked or obstructed in any manner

Power Cord Set Requirements

The power cord set supplied with your instrument meets the requirements of the country where you purchased the instrument. If you need a different power cord, contact CETAC Technologies.

Power Cord Safety Maintenance

The operator should check the power/signal supply cord condition. The equipment should not be operated if the mains inlet is cracked or broken. Any obvious damage to the case (from a drop or fall) should be checked by service personnel for loose or damaged parts. See individual parts lists for approved replacement parts

Mains Disconnect

Power mains disconnect is accomplished by unplugging the power cord at the power supply or at the wall outlet. Ensure the power cord is easily accessible and removable, in the event of an emergency which requires immediate disconnection.

WARNING	**SHOCK HAZARD** **Ensure that power cord is disconnected before removal of any covers.**

Cleaning Instructions

For additional cleaning information, see "cleaning" in the index.

To clean the exterior surfaces of the instrument, complete the following steps:

1. Shut down and unplug the instrument.
2. Wipe the instrument exterior surfaces only using a towel dampened with a lab-grade cleaning agent.
3. Repeat step 2, using a towel dampened with clear water.
4. Dry the instrument exterior using a dry towel.

WARNING

SHOCK HAZARD
Do not allow any liquid to enter the instrument cabinet other than as intended through the specified tubing, or come into contact with any electrical components. The instrument must be thoroughly dry before you reconnect power, or turn the instrument on.

Operating Environment

WARNING

SHOCK HAZARD
To reduce the risk of fire hazard and electrical shock, do not expose the unit to rain or humidity. To reduce the risk of electrical shock, do not open the cabinet. All maintenance is to be performed by an Authorized CETAC Service Provider.
Protection provided by the equipment may be impaired if the equipment is used in a manner not specified by the manufacturer.

WARNING

SHOCK HAZARD
Equipment is not intended for wet locations. Miscellaneous liquids in the equipment could cause hazardous conditions.

WARNING

EXPLOSION HAZARD
Do not operate in an explosive atmosphere.

Explanation of Caution and Warning Notices

Warning symbol marked on equipment. This symbol means "Attention! Refer to the manual."

WARNING	**The WARNING notice denotes a hazard. It calls attention to a procedure, practice, or the like, that, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood**

CAUTION	The CAUTION notice denotes a hazard. It calls attention to a procedure, practice, or the like, that, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

Avertissements en Français

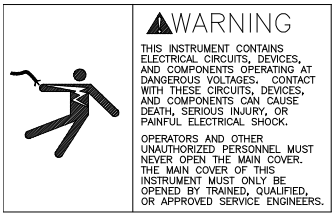
This section provides French translations of notices which may appear on the instrument or on other instruments used as part of the measurement system.

WARNING
FOR CONTINUED PROTECTION AGAINST RISK OF FIRE, REPLACE ONLY WITH FUSES OF THE SPECIFIED TYPE AND CURRENT RATING.

FOR CONTINUED PROTECTION AGAINST RISK OF FIRE, REPLACE ONLY WITH FUSES OF THE SPECIFIED TYPE AND CURRENT RATING.

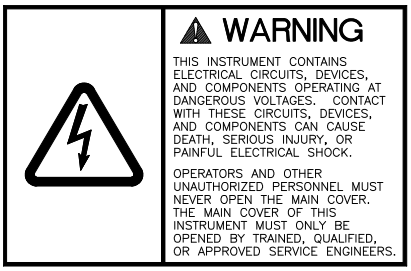
⚠ AVERTISSEMENT

POUR UNE PROTECTION CONTINUÉ CONTRE LES RISQUES D'INCENDIE, REMPLACER UNIQUEMENT PAR DES FUSIBLES DE MÊME TYPE ET AMPÈRAGE.



⚠ AVERTISSEMENT

TOUT CONTACT AVEC LES HAUTES TENSIONS PEUT ENTRAINER LA MORT OU DES BLESSURES SÉVÈRES. CE PANNEAU NE DOIT ÊTRE ENLEVE QUE PAR UN RÉPARATEUR QUALIFIÉ.



⚠ AVERTISSEMENT

TOUT CONTACT AVEC LES HAUTES TENSIONS PEUT ENTRAINER LA MORT OU DES BLESSURES SÉVÈRES. CE PANNEAU NE DOIT ÊTRE ENLEVE QUE PAR UN RÉPARATEUR QUALIFIÉ.

⚠ AVERTISSEMENT

NE PAS GLISSER LA MAIN SOUS OU DERIERE LES ECRANS THERMIQUES DU FOUR. GARDER LA PORTE D'ACCES AU DEVANT DU BOITIER BIEN FERMEE POUR ASSURER LA PROTECTION CONTRE LES BRULURES.

⚠ AVERTISSEMENT

TOUT CONTACT AVEC LES HAUTES TENSIONS PEUT ENTRAINER LA MORT OU DES BLESSURES SÉVÈRES. CE PANNEAU NE DOIT ÊTRE ENLEVE QUE PAR UN RÉPARATEUR QUALIFIÉ.

⚠ AVERTISSEMENT

TOUT CONTACT AVEC LES HAUTES TENSIONS PEUT ENTRAINER LA MORT OU DES BLESSURES SÉVÈRES. CE PANNEAU NE DOIT ÊTRE ENLEVE QUE PAR UN RÉPARATEUR QUALIFIÉ.

⚠ WARNING
HIGH LEAKAGE CURRENT
ENSURE PROPER GROUNDING

⚠ AVERTISSEMENT

COURANT DE FUITE ÉLEVÉ — FORNIR UNE MISE À LA TERRE EFFICACE.

⚠ AVERTISSEMENT

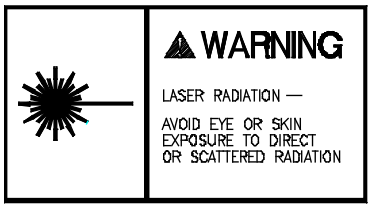
SURFACES CHAUDES, LAISSER LE COUVERCLE HERMÉTIQUEMENT FERMÉ. POUR ACCÉDER, METTRE LA TEMPÉRATURE DU FOUR À ZÉRO, OUVRIR LE COUVERCLE ET LAISSER REFROIDIR 5 MINUTES AVANT DE TOUCHER LA VERRERIE OU TOUTE SURFACE MÉTALLIQUE INTÉRIEURE.

On (Supply)

Off (Supply)

⚠ AVERTISSEMENT

POUR LA PROTECTION PERMANENTE CONTRE UN CHOC ÉLECTRIQUE, UNE BRÛLURE DES YEUX (RADIATION UV) OU DE LA PEAU, LAISSER LE COUVERCLE HERMÉTIQUEMENT FERMÉ LORSQUE L'APPAREIL EST SOUS TENSION. LAISSER REFROIDIR 5 MINUTES (APPAREIL ÉTEINT) AVANT D'ENLEVER LE COUVERCLE.



⚠ AVERTISSEMENT

RAYONNEMENT LASER —
ÉVITER TOUTE EXPOSITION DES YEUX ET DE LA PEAU
AU RAYONNEMENT DIRECT OU DIFFRACTE.

The cooling system, located in the laser power supply, is filled with **DISTILLED WATER**.
DO NOT fill with any other type of fluid!
The cooling system should contain a sufficient amount of distilled water. The fault light will come on if the coolant is in interlock mode.

⚠ AVERTISSEMENT

LE SYSTÉME DE REFROIDISSEMENT EST REMPLI D'EAU DISTILLÉE. **EVITER LE GEL**, OU L'APPAREIL SERA DÉFINITIVEMENT DÉTÉRIORÉ

COOLING FAN OBSTRUCTION
The Laser Power supply cooling fan should remain unobstructed at all times.
Do not operate the instrument if the cooling fan is blocked or obstructed in any manner

Electromagnetic Interference

FEDERAL COMMUNICATIONS COMMISSION (FCC) NOTICE

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a commercial installation.

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential environment is likely to cause harmful interference, in which case the user will be required to correct the interference at his expense.

MODIFICATIONS

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by CETAC Technologies may void the user's authority to operate the equipment.

CABLES

Connections to this device must be made with shielded cables with metallic RFI/EMI connector hoods to maintain compliance with FCC Rules and Regulations.

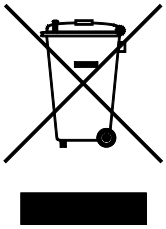
CANADIAN NOTICE

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus as set out in the interference-causing equipment standard entitled "Digital Apparatus" ICES-003 of the Department of Communications.

AVIS CANADIEN

Cet appareil numerique respecte les limites de bruits radioelectriques applicables aux appareils numeriques de Classe A prescrites dans la norme sur le materiel brouilleur: "Appareils Numeriques," NMB-003 edictee par le ministre des Communications.

Explanation of Regulatory Marks



Do not dispose in domestic household waste.

The affixed label indicates that you must not discard this electrical/electronic product in domestic household waste, in compliance with the European Waste Electrical and Electronic Equipment Directive (WEEE, 2002/96/EC).

For instructions on how to return end-of-life equipment, producer-supplied electrical accessories, or auxiliary items for proper disposal please contact the supplier or importer. In the event a supplier cannot be reached, contact CETAC Technologies customer service department at 1 (800) 369 2822.

CE

The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives.

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8 Glossary

213nm: Refers to the wavelength of the laser light used for ablation in the low UV part of the spectrum.

Analytical Instrument: The instrument, typically an ICP or ICP-MS, to which the laser ablation system is connected.

Aperture: Laser spot size control, producing crater sizes ranging from 10–200 mm. The aperture is controlled by the DigiLaz III software.

CCD: Charge coupled device video sensor.

Defocus: The distance in µm that the Z-stage moves down which makes a larger spot size at lower energy density.

Depth Profile: Software-controlled method for spatial profiling that can move the Z-stage up at a specified rate.

Flat Top Energy Profile: Beam profile of the UV Nd:YAG laser at 266 nm producing superior pit morphology.

He: Helium. Used as the sample carrier gas.

Host Computer:The computer that controls operation of the LSX-213 laser ablation system. Typically, this computer also controls the analytical instrument.

Hz: Hertz

ICP-OES: Inductively coupled plasma optical emission spectrometer. OES is used as a synonym for AES (atomic emission spectrometer).

ICP/ICP-MS: Inductively Coupled Plasma/Inductively Coupled Plasma-Mass Spectrometer.

ICP Software: The measurement automation software on the host computer which controls the analytical instrument. “ICP” in this context can refer to both Instrument Control Program and Inductively Coupled Plasma spectroscopy. Examples of ICP software include iTEVA™, WinLab32™, ICP-MS Expert™, and ChemStation™.

ID: Inside Diameter.

LASER: Light Amplification by Stimulated Emission of Radiation.

Laser head: Component that generates the laser beam.

LED: Light-Emitting Diode.

LSX-213: The CETAC LSX-213 Laser Ablation System.

Macro: The software in the electronics module which intercepts and acts upon autosampler commands.

Nd:YAG: Neodymium: Yttrium Aluminum Garnet. Refers to the type of laser used in the LSX-213.

Pulse Repetition Rate: The number of laser pulses per second expressed as Hz, same as frequency.

Raster: Moving the X-Y-Z stage to allow ablation of a series of spots in a line or area.

Sample cell: Component that contains the sample for laser ablation. Carrier gas flowing through the sample sell carries the ablated material to the analytical instrument.

Scan: Moving the X-Y-Z stage for continuous ablation over a line or area.

VDC: Volts Direct Current.

X-axis: The left-and-right axis of the X-Y-Z translation stage.

Y-axis: The fore-and-aft axis of the X-Y-Z translation stage.

Z-axis: The up-and-down axis of the X-Y-Z translation stage.

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