LDY300-PIV Series

User's Manual
&
Laser System Test Results

Document Control

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1.0	First Release
2.0	Updated to 2013 product changes
2.1	Update ZPC Chiller / Section 1 & 2 Revisions

CONTENTS

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PREFACE

Who should read this user manual?

All personnel who will unpack, install, use or maintain this laser system.

How to use this manual

This manual contains important information that is required to allow the safe installation, use and maintenance of this laser system.

You should only attempt the procedures contained in this manual after they have been read and fully understood, and in particular Section 1 – SAFETY.

Certain aspects of the laser maintenance should only be undertaken by personnel who have received training from Litron or one of our authorised representatives. These procedures are highlighted where appropriate.

Troubleshooting

The troubleshooting section provides information to assist the user in the diagnosis of common faults and how to identify the cause of interlocks being triggered.

If there is any doubt or uncertainty about the laser systems behaviour or performance please contact either Litron Lasers, the representative or the system integrator who initially supplied the laser system.

Customer Service

Litron Lasers Ltd.
8 Consul Road,
Rugby
CV21 1PB
United Kingdom

Tel: +44 (0) 1788 574444
e-mail: service@litron.co.uk

1. SAFETY

WARNING: LASER RADIATION
THE LDY-PIV SERIES OF LASERS ARE CLASS 4 LASER DEVICES AND ARE CAPABLE OF EMITTING LEVELS OF BOTH VISIBLE AND INVISIBLE RADIATION THAT CAN CAUSE DAMAGE TO THE EYES AND SKIN. IT IS THEREFORE IMPERATIVE THAT THIS MANUAL IS FULLY READ AND UNDERSTOOD PRIOR TO USING THE LASER SYSTEM.

There are different aspects of laser safety that will be outlined in this chapter, General safety, Operational safety, Optical safety and Electrical safety. Finally the Safety and Information labels that are affixed to the lasers are presented and their meanings described.

1.1 OVERVIEW

The LDY-PIV series of DPSS Nd:YLF lasers are CLASS 4 laser devices and should be operated with due care and attention paid to the safety practices outlined in this manual. Whilst these lasers have been designed to comply with all necessary legislation pertaining to safety and electromagnetic compatibility, if used incorrectly harm to the user or others may result.

Safety terms used in this manual:

Danger 

Indicates an imminent / immediately hazardous situation which, if not avoided, will result in death or serious injury.

Warning 

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

Caution 

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
It is also used to alert the user against unsafe working practices that can potentially result in damage to the equipment.

1.2 GENERAL SAFETY

The operation of the LDY-PIV series of pulsed Nd:YAG lasers should always be in accordance with the procedures described within this manual. As the laser output is potentially harmful, the user and those in the same room, or optical proximity to the laser should be aware of its operation and the potential hazards. In order to minimise the danger posed by the laser output, there are several steps that the user can take.

These include, but are not limited to:

- Never operate the laser in a room where light can escape through windows or doors. If possible interlock the door(s) giving access to the room using the external interlock connector on the power supply unit.
- Always ensure that adequate and proper protective eyewear is provided for all persons who may be exposed to radiation from the laser during its operation.
- If possible mount the laser below eye level.
- Assume that all reflections pose a danger and never knowingly look at a reflecting surface even when wearing protective eyewear.
- Be aware of back reflections from energy monitors and dump them safely.
- Keep the intra-cavity safety shutter closed whenever the output is not needed and if possible stop the laser.
- Always dump the beam safely onto an absorbing target. Be mindful of the fact that the target will increase in temperature and may pose a fire hazard.
- Always post appropriate CLASS 4 laser warnings on all entrances to the room where the laser is used.
- Try to ensure that the beam path is shrouded, to avoid any radiation escaping.
- Always ensure the laser is secured suitably so that it cannot be moved during operation.
- Always ensure the connections to the laser head and power supply are secured and do not pose a tripping hazard.

1.3 OPERATIONAL SAFETY

All Litron laser systems are equipped with a full suite of interlocks. The function of an interlock can be either:

1. To shut the laser down when further operation in the current state may cause damage to the system **or**
2. To prevent the system being operated in an unsafe state that could result in harm to the user.

The function detailed in point 1 also acts as a self-check during laser start up and operation. In addition all interlocks are latched so that if a transient fault occurs (such as opening and closing a door connected to the external interlock), the user can readily see the cause for the system shutdown. This is an important diagnostic tool. A full description of the interlocks is presented in the Chapter 3.

The interlocks that are of concern in this section are those detailed in point 2. As mentioned in Section 1.2 an external interlock is present so that the room or enclosure that houses the laser system can be interlocked. This helps to protect the user and others from accidental exposure to laser radiation. In addition to the external interlock, the covers for the laser head and PSU are also interlocked. The following points should always be adhered to:

- Never operate the laser with the covers removed from the laser head and interlocks defeated.
- Never operate the laser with the covers removed from the power supply, lamp connections, and lamp. Lethal voltages are present that may cause death or serious injury.

1.4 OPTICAL SAFETY

Laser emissions from the LDY-PIV series of DPSS CW Nd:YLF lasers are sufficiently intense to cause blindness. Blindness may result not only from direct incidence of the beam on the eye, but from any type of reflection either diffuse or specular. For certain model series and under certain situations the radiation emitted can be invisible and the danger may not be obvious. It is absolutely necessary that protective eyewear with a sufficiently high optical density at the wavelengths emitted by the laser is worn at all times when operating the laser.

WARNING: LASER RADIATION

PROTECTIVE LASER GOGGLES MUST ALWAYS BE WORN WHEN OPERATING THE LASER. THE GOGGLES MUST PROTECT AGAINST ALL WAVELENGTHS THAT CAN BE EMITTED INCLUDING HARMONICS. THESE WAVELENGTHS ARE 1064nm or 1053nm AND MAY INCLUDE DEPENDING UPON THE MODEL 532nm 527nm , 355nm, 266nm AND 213nm. ALWAYS AVOID DIRECT EYE OR SKIN CONTACT WITH ANY RADIATION BE IT LASER OR COLATERAL.

The CLASS 4 Laser Safety Warning label (LABEL 1) must be consulted to establish the exact wavelengths and the energy levels emitted by this laser.

The emission indicators on the laser head and power supply unit warn of laser emissions. It should be assumed that a hazardous emission exists if either of these is illuminated. The emission indicators are of a colour that can be viewed through all protective eye-wear appropriate to the operation of this device as is required by **BS EN 60825-1:2007**.

All laser systems in the LDY-PIV range are supplied with an intra-cavity electronic safety shutter that is electronically verified. When the laser is turned on the shutter is automatically closed so that the system will not start up in a condition where lasing can occur. If the shutter is not in the verified position then the laser will not start.

1.5 ELECTRICAL SAFETY

It is necessary to the operation of a laser system of this type that high voltages and large stored energies are required. The cover of the power supply should never be removed. There are no user serviceable parts within the power supply and any fault should be reported to Litron, who will if necessary arrange for the unit to be serviced by a qualified person.

Equally, high voltages exist within the laser head. When removing the cover from the laser head always remove the power from the mains to the power supply unit and wait at least 5 minutes for all capacitors within the power supply to have fully discharged.

DANGER: ELECTROCUTION

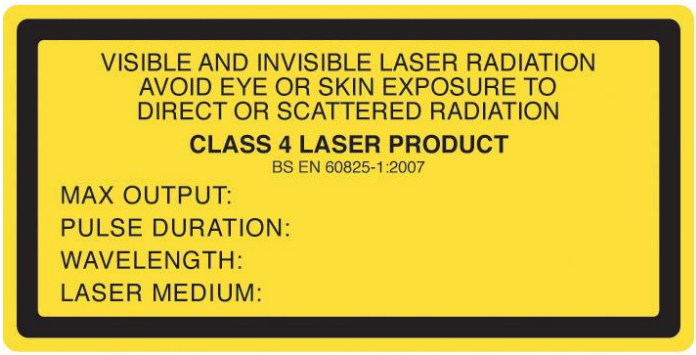
HIGH AND POTENTIALLY LETHAL VOLTAGES AND STORED ENERGIES ARE PRESENT WITHIN BOTH THE POWER SUPPLY AND LASER HEAD DURING OPERATION AND STANDBY. ALWAYS ISOLATE THE POWER SUPPLY FROM THE MAINS AND WAIT AT LEAST 5 MINUTES BEFORE REMOVING THE COVER TO THE LASER HEAD. NEVER REMOVE THE INNER COVER TO THE POWER SUPPLY.

1.6 SAFETY AND INFORMATION LABELS

In this section the safety and information labels that are attached to the laser head and PSU are shown and a brief description is given where necessary. Certain labels are present on all variants of the Nano, LPY and LDY series, others will be present only on certain models. Section 1.7 shows the positions of these labels on the laser head and PSU. For a PIV system there are two laser heads and laser 1 is identified with a red label and laser 2 with a green label.

LABEL 1

The laser output declaration label, describes the laser type as a CLASS 4 LASER PRODUCT. The stated energy output is always greater than the maximum possible output. This ensures that adequate eye protection and beam handling precautions are observed. This label is found on the laser head. For a system fitted with harmonics the label will indicate VISIBLE & INVISIBLE RADIATION, and the wavelengths noted. The values for this label of MAX OUTPUT, PULSE DURATION, WAVELENGTH AND LASER MEDIUM are given in the test results supplement.



LABEL 2

The emission warning label is found on the laser head and cover, and warns of possible emission if the laser is run with the laser head cover removed and the interlocks defeated. The laser should not be operated in this condition.

LABEL 3

This label is found on the laser head and warns of emission from an aperture. On the Nano, LPY and LDY series of lasers, depending upon the configuration of the laser, there may be more than one aperture from which radiation is emitted. The user must therefore familiarize themselves with the location of all such apertures before using the laser. If the laser system produces just infra-red light then the aperture warning label will indicate only INVISIBLE RADIATION. If the system produces the harmonic outputs of 1064nm or 1053nm then the label will indicate VISIBLE AND INVISIBLE LASER RADIATION EMITTED FROM THIS APERTURE.

LABEL 4

These labels are located on either side of the laser head case, and warn of laser radiation emission.

LABEL 5

These labels are located on panels that if removed would expose electrical circuits that operate at high voltages and therefore pose a risk of electric shock.

UNDER NO CIRCUMSTANCES SHOULD THE LASER BE OPERATED WITH THESE PANELS REMOVED.

LABEL 6

This is used in conjunction with the risk of electric shock label, and is mounted on any panels that if removed, would expose electrical circuits that operate at high and potentially lethal voltages.

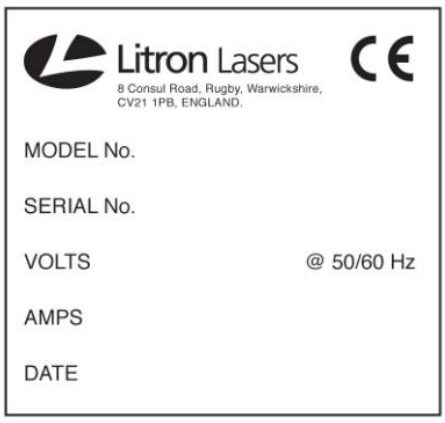
UNDER NO CIRCUMSTANCES SHOULD THE LASER BE OPERATED WITH THESE PANELS REMOVED.

LABEL 7

This label will be attached to panels that should only be removed when the power supply is isolated from the mains input supply. At least 5 minutes should be allowed between isolating from the mains supply and removal of the relevant cover.

LABEL 8

This label gives important information concerning the operating electrical inputs to the system along with the PSU model and serial numbers.



Note: On certain models this label is printed directly onto the power supply unit

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LABEL 9

This label shows the model and serial number of the laser system.

LABEL 10

This label gives warning that the Harmonic Generator crystal assembly is heated to 100°C, and as such, care should be taken when making adjustments to the crystal. This label is not present on all models.

LABEL 11

FDA – CDRH Compliance Declaration Label. This label provides confirmation that the laser system is compliant with the appropriate requirements of the United States FDA and CDRH laser safety standard.

1.7 SAFETY AND INFORMATION LABEL LOCATIONS - EXTERNAL

All variants of the LDY-PIV series of laser systems have safety and information labels fitted. In the figures that follow there are examples of where these labels are fitted to the laser heads and PSU.

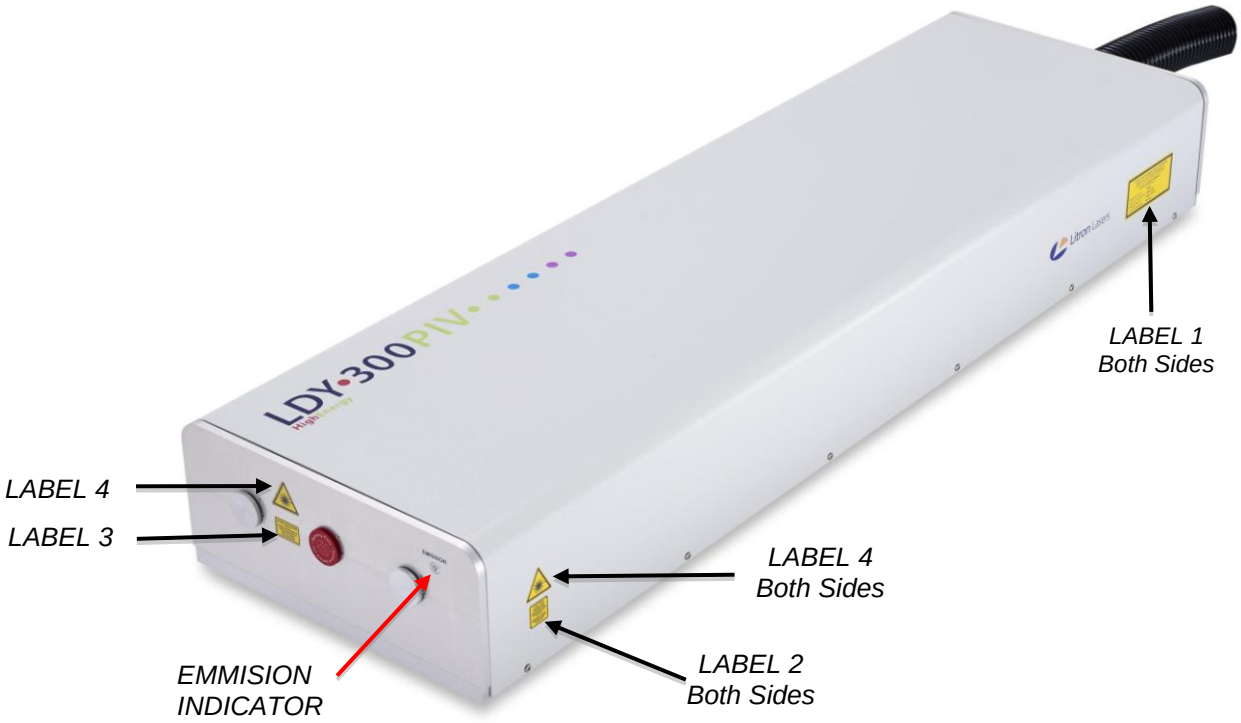


Figure 1:LDY-PIV Laser head – External Label Positions

Figure 2:LDY-PIV Laser Head - Rear Label Positions

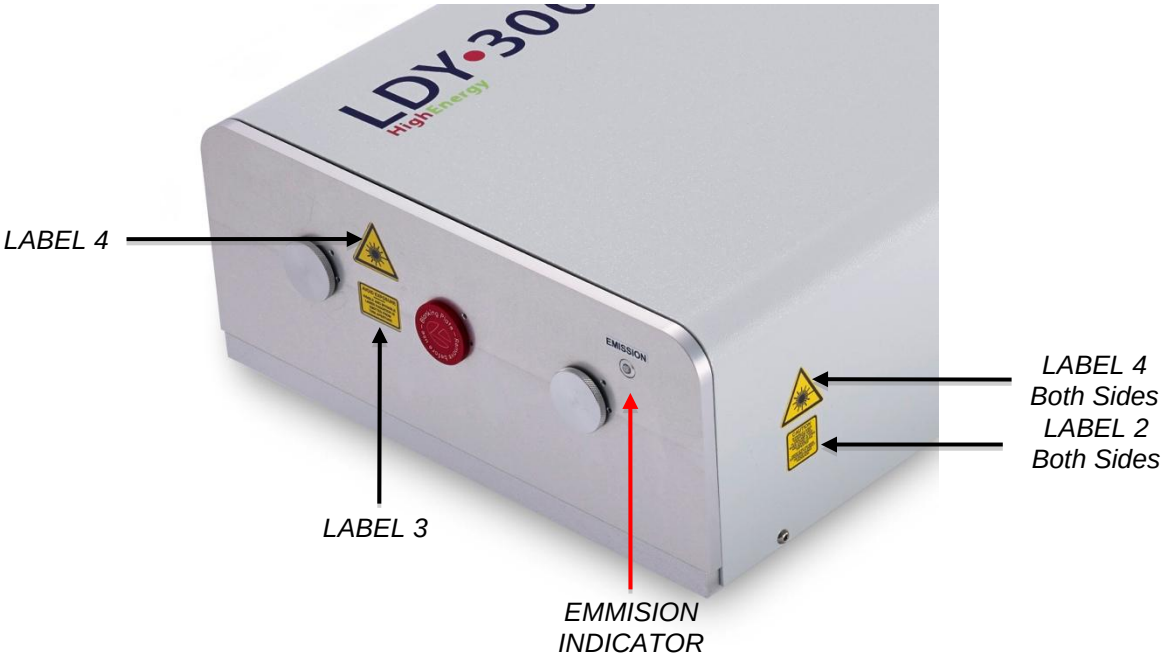


Figure 3: LDY-PIV Case Labels – Beam Exit

1.8 SAFETY AND INFORMATION LABEL LOCATIONS – INTERNAL

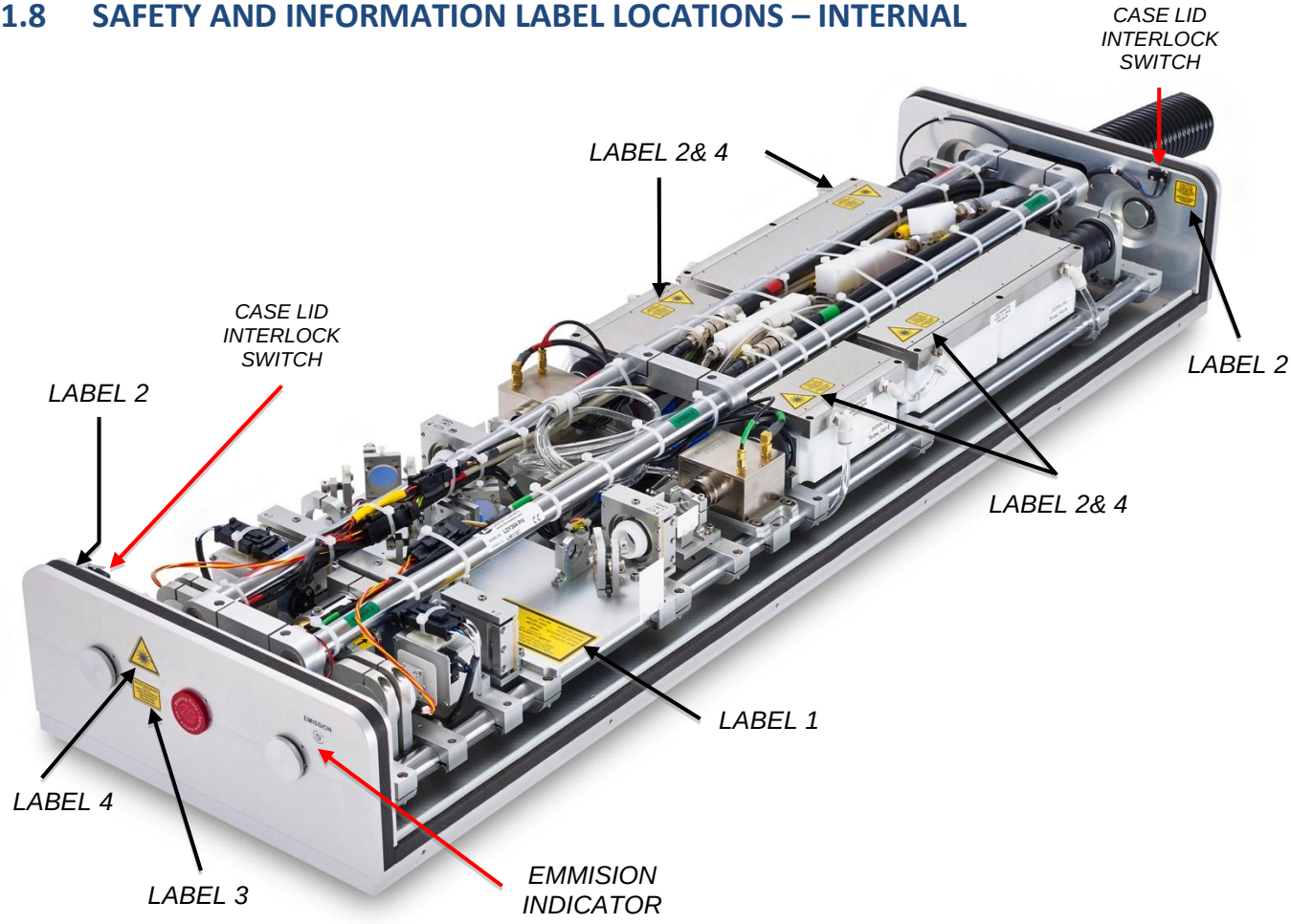


Figure 4: LDY-PIV Internal Labels

1.9 LDY-300 INTERGRATED PSU LABELS LOCATION

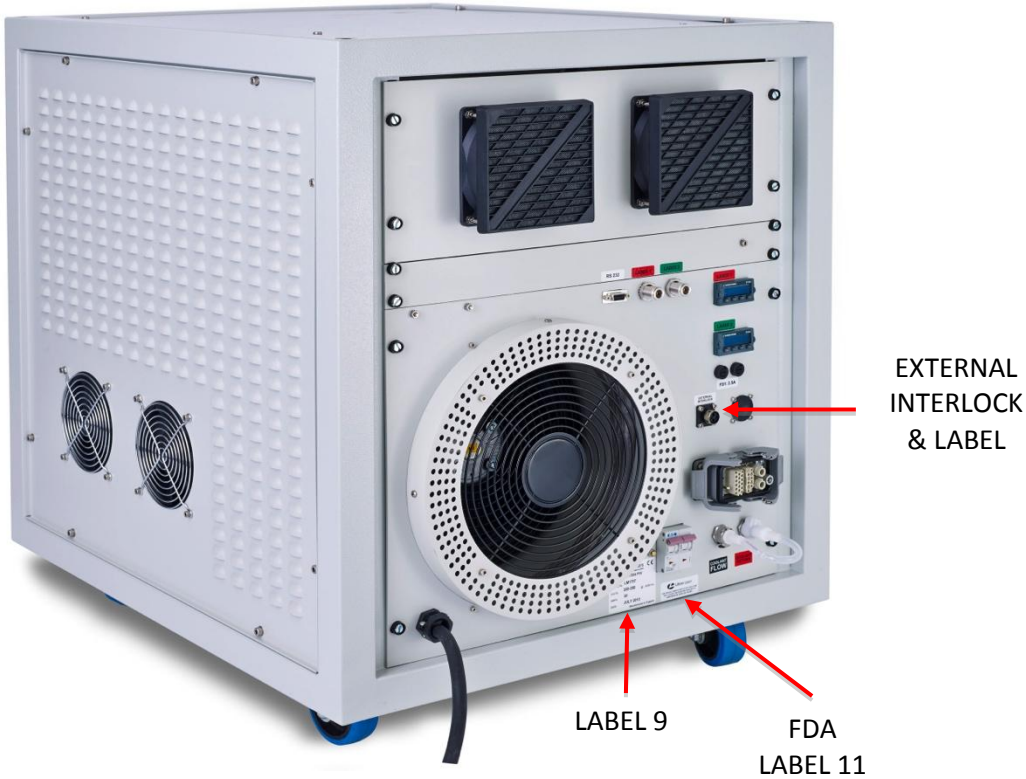


Figure 5:LDY-LPU Label positions

2. GENERAL DESCRIPTION

2.1 PIV LASER SYSTEM

LDY-PIV series lasers are a dedicated configuration primarily for use as an illumination source for Particle Imaging Velocimetry (PIV). The system uses two CW Q-switched Nd:YLF DPSS laser resonators producing infrared laser light at 1053nm which is converted to visible 527nm laser light by an intra-cavity Harmonic Generation Assembly (HGA). The harmonic generator produces a laser output at 527nm (green). To ensure that both laser outputs can be used with a single set of external optics the 527nm laser beams are combined using polarisers and exits through a single port of the laser head.

The use of two independently pulsed and controlled resonators allows the generation of a double pulse output with inter-pulse separation times of less than ten Nano seconds where required. This ultra-short inter-pulse separation cannot be achieved using a single resonator laser fitted with an electronic double pulse option. The short pulse duration achieved by acousto-optic Q-switching the laser resonator allows the motion of fast moving particles to be frozen in the image.

In addition the two beams are pre-aligned at the factory to be co-axial and exit the laser aligned orthogonal to the output faceplate. The output faceplate for the LDY-PIV series is also supplied with the correct holes and screw threads to allow the fitment of laser light sheet optics from all the main manufactures of these devices. The laser control section of the Power Supply Unit (PSU) is fitted with TTL inputs that are compatible with the timing and camera synchronisation generators supplied by all the principle manufacturers of PIV software and control systems.

2.2 LASER HEAD

The laser head comprises two independent laser oscillators, the 1053nm polarisation beam combination optics and the 527nm harmonic generation and separation optics are all mounted onto an thermally stable Invar optical rail system.

The LDY-PIV series of lasers use a multiple rod stable oscillator configuration, especially optimised for generating a uniform beam to create light sheets with. The stable resonator design provides for a smooth and homogeneous beam profile in the near and far field. This is essential in illumination applications to ensure the light intensity is consistent in the image plane where the particles are being measured.

The Nd:YLF rods are pumped by infra red laser diodes driven by a stabilised solid state power supply. The power supply actively monitors the drive current to the pump diodes to ensure a stable output. Q-switching of the laser pulse is via an acousto optic Q-switch which is driven by an RF power driver that is designed and manufactured by Litron.

A monitored mechanical intra-cavity safety shutter is fitted in both resonators. This prevents any laser output at anytime when it is closed, even if the diodes are pumping the rods and the Q-switch controls are activated. The safety shutter circuit is linked to the laser interlock and monitoring circuits, if the shutter does not respond to the command to open or close the laser will shut down to prevent exposure to laser radiation.

LDY-PIV series lasers are fitted with polarisation based beam combination optics to allow the two laser beams to be aligned co-axially with each other. The 527nm HGA is actively heated and thermally stabilised at ~ 70 ˚C. The active temperature stabilisation ensures consistent tuning of the 527nm crystal irrespective of the local ambient temperature.

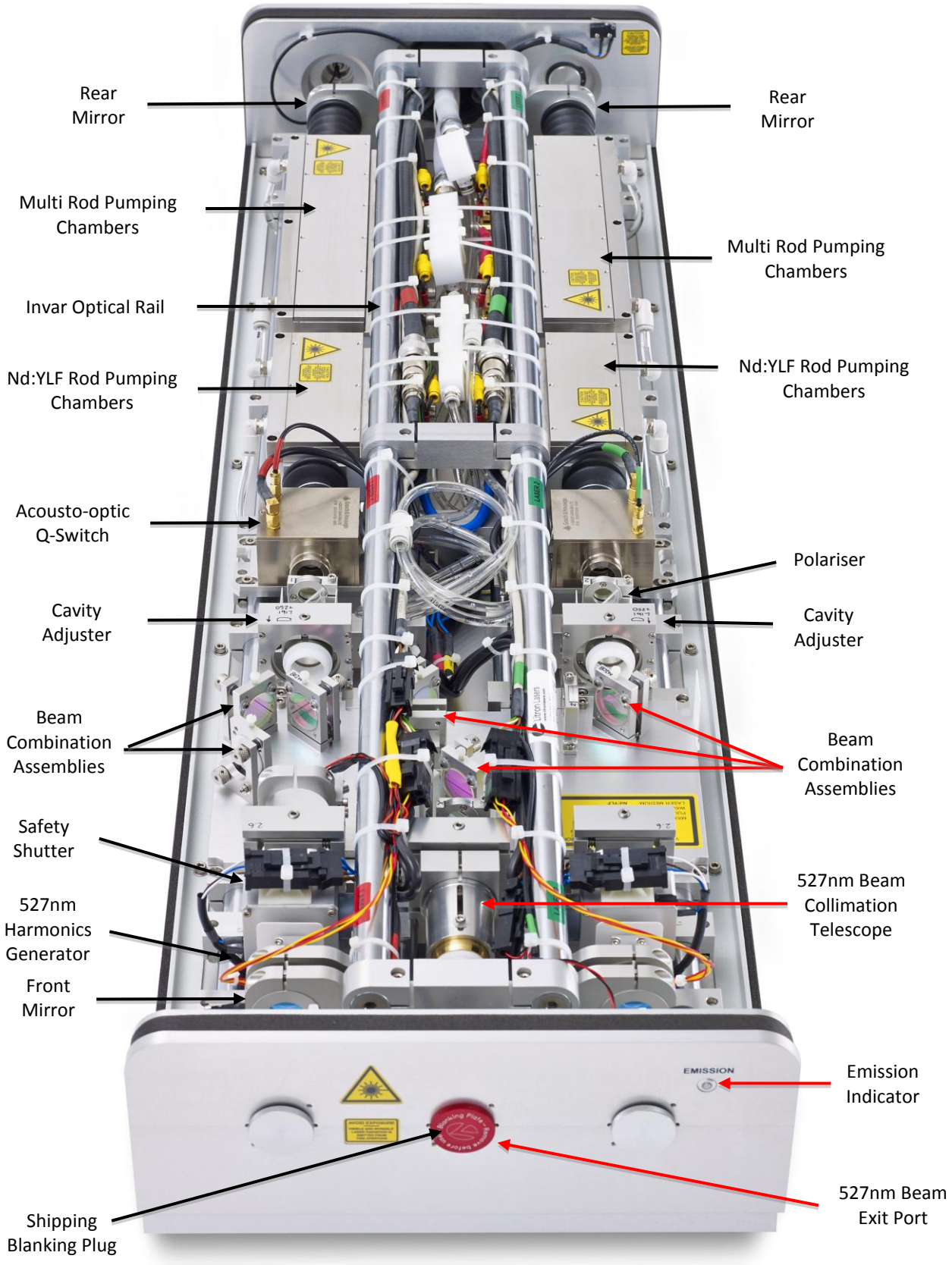


Figure 6:LDY-PIV Laser Head

2.3 LDY POWER SUPPLY

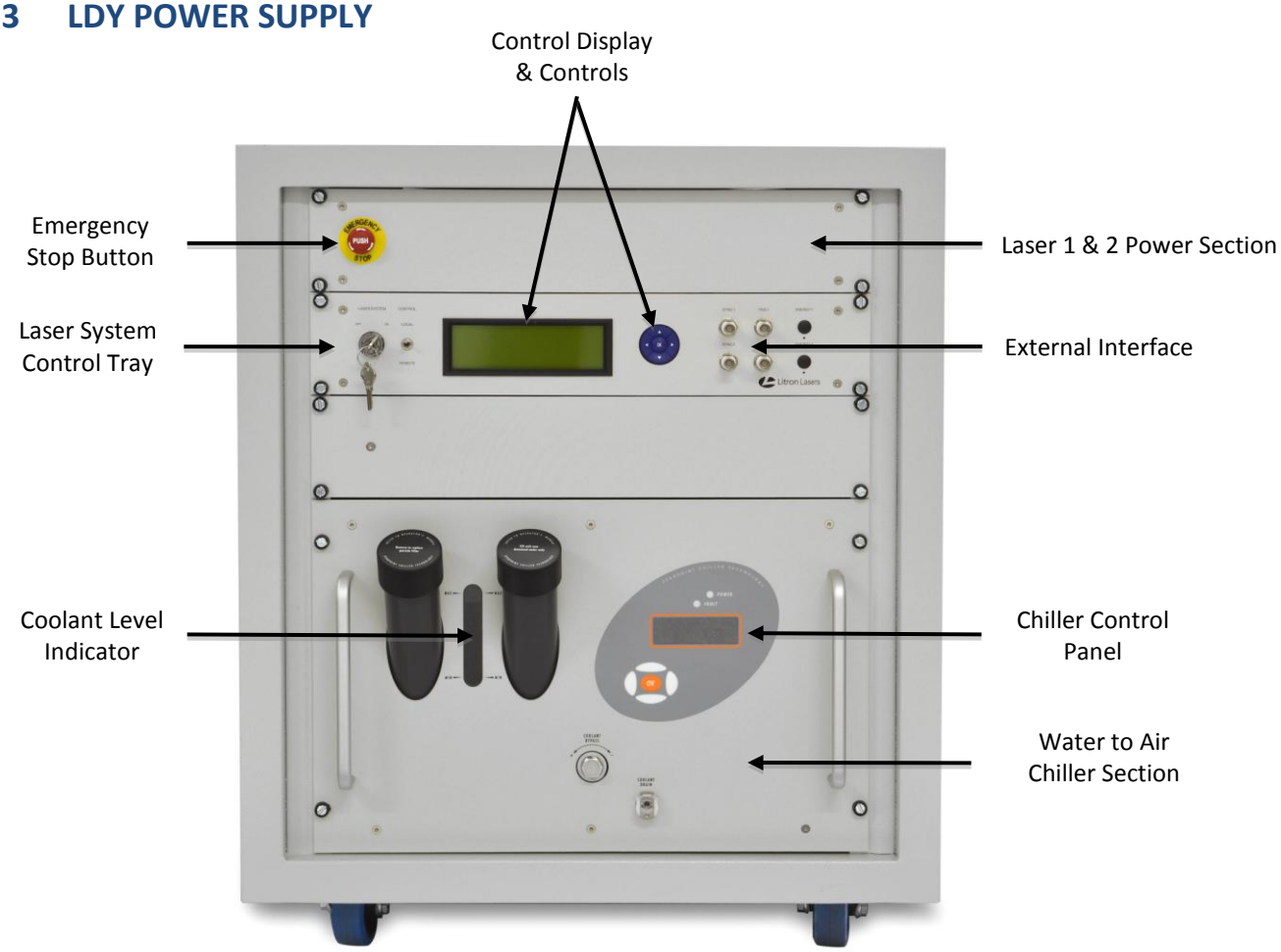


Figure 7:LDY-LPU Power Supply Configuration

2.3.1 Laser System Control

The laser control tray houses all the laser system control and interface electronics to allow the laser to operate and to be used as an illumination source for PIV and other imaging applications. The laser system is controlled via an RS232 communications link. The system control tray has a fully functioning interface to allow the laser to be operated locally without the need for a computer or Laptop PC. The optional Windows ™ based laser control software is supplied on the USB Stick media supplied with the laser system. The manual for using this software is also included electronically on that same media.

2.3.2 Power Section

The power tray for the LDY Series contains the high current 48V power supplies used to drive the laser diode based pumping sources for the Nd:YLF rods. The power supplies are totally solid state and use the latest in switched mode DC power technology. This is critical to ensure consistent and uniform output from the diodes which translates directly into the stability of the laser output stability.

Litron Lasers has designed and manufactured all the dedicated power conditioning and management electronics required by laser diodes when used for pumping solid state lasers. These electronics ramp the current to the diodes and provide smart power management to ensure the safe running and maximum longevity and protection of the pump diodes.

2.3.3 Laser Cooling Section

The lower part of the LDY-PIV series PSU contains a water to air active chiller unit for the thermal management of the de-ionised water used to cool the laser diodes and the laser rods during operation.

The cooling section comprises the following:

1. Water reservoir – with filter Cartridge
2. Water Pump – drives water up to the laser head and through the heat exchanger.
3. Active, refrigeration based heat exchange system.
4. Sensor Suite –Water level, water flow, water temperature and ambient temperature are monitored.
5. Microprocessor Controller:
    a. Monitors the water temperature
    b. Monitors the air temperature
    c. Controls the cooling fan speed

3. INSTALLATION

3.1 UNPACKING THE LASER SYSTEM

The LDY PIV series of DPSS Nd:YLF laser systems are sensitive pieces of optical equipment. Whilst the lasers are very robust and have been designed to cope with normal every day use, care should be taken to ensure that the laser head is not subjected to misuse which could cause a loss of alignment and a reduced laser output.

CAUTION: RISK OF DAMAGE

PLEASE ENSURE THAT THE ELECTRICAL AND WATER CONNECTORS FOR LASER HEAD ARE CONNECTED CORRECTLY TO THE CORRESPONDING CONNECTORS. LASER 1 CONNECTORS ARE COLOUR CODED AS RED AND LASER 2 CONNECTORS ARE COLOUR CODED AS GREEN

CAUTION: RISK OF DAMAGE

Nd:YLF IS A BRITTLE AND FRAGILE MATERIAL. EXTRA CARE MUST BE TAKEN WHEN MOVING THE LASER HEAD TO ENSURE IT IS NOT SUBJECT TO ANY SEVERE IMPACTS THAT MAY DAMAGE THE INTERNAL OPTICAL PARTS – SUCH AS BEING DROPPED.

The laser system should carefully be removed from the packing crate. The contents of the crates should be, for a standard system with no optional extras:

Table 1: Inventory of LDY-PIV series laser.

Quantity	Description
1	Dual cavity LDY-PIV laser head with conduit
1	Power supply
1	Set of keys
1	External interlock plug
1	Power cable
1	Operator's Instruction Manual – this Document
1	Laser system test results – at the back of this manual

Please ensure that all items are present before proceeding with the installation. Also please read these instructions fully before continuing with the installation.

3.2 LASER SYSTEM INSTALLATION LOCATION

The installation location and working environment for the laser should be chosen with the following considerations having been taken into account:

- **Safety** - A safe location that has some form of access control to prevent accidental exposure to laser radiation.
- **Accessible** – easy access to the laser head and adequate clearances as described later in this guide.
- **Services** – should be located within easy reach of the mains lead.
- **Environment** – adequate air conditioning must be provided and can in some cases be critical for the laser system performance. However air ducts of forced air conditioning systems should not be located above or close to the laser head.
- **Mechanically robust furniture** –The bench or table for the laser head must be suitably strong enough to bear this weight with ease.
- **Vibration isolation** – should you deem this necessary then a suitable table must be provided before installation. Care should be taken in respect of the floor and building structure too.
- **Maintenance** – at some point in the future the laser system may need to be accessed for maintenance or for an upgrade.

3.3 WEIGHTS AND DIMENSIONS:

3.3.1 Power Supply Unit

Please confirm the size of the PSU for your laser system. The table below shows standard configurations for most models. Certain custom laser systems may differ from the size below.

Table 2: Weight and dimensions of power supplies

PSU Size:	PSU Dimension Width x Height x Depth	PSU Weight	Laser Models
LDY 19”	605mm x 740mm x 700mm	100 Kg	All Models

3.3.2 Laser Heads

In all cases the weights given are estimates based on typical configurations. Please verify the laser head configuration of the system you have ordered before or at the time of ordering.

Table 3:Weight and dimensions of laser heads.

Laser Head Configuration	Laser Head Width and Height	Laser Head Length	Laser Head Weight
LDY301-PIV	326mm x 139mm	900mm	65 Kg
LDY302-PIV	326mm x 139mm	900mm	70 Kg
LDY303-PIV LDY303HE-PIV LDY304-PIV	326mm x 139mm	1100mm	85 Kg

3.3.3 Ambient Considerations – Air Cooled PSU

The laser system power supply requires constant ventilation while running. The fans fitted to the supply are designed to meet the system requirements when the specified operating ambient conditions are met.

Customers should be aware that the power supply will create an additional heat source in the installation location. Suitable air conditioning should be provided at the location to maintain the ambient temperature with the power supply operating.

The chiller uses a large diameter, high volume electrical fan to move the air over the heat exchange matrix. This fan can be noisy and consideration should be taken regarding the noise and supply of sufficient air at the ambient specified below.

Table 4:Ambient conditions for LDY-PIV systems.

Laser Model Series	LDY301	LDY302	LDY303/304
Max Air Temp at Inlet	30°C (95°F)		
Min Air Temp at Inlet	5°C (41°F)		
Ambient Humidity [non condensing]	0% -80%		
Thermal Load to Air / Ambient (W)	~1000	~1500	~2500

3.3.4 Chiller Airflow and Venting of Hot Exhaust Air

Positioning of the power supply unit is very important to make sure that the chiller unit receives the correct cool air flow.

Failure to allow enough room around the power supply unit may result in the hot exhaust air being re-circulated back into the chiller. In confined areas, or when used in high ambient temperature conditions, the hot exhaust air can be vented away from the chiller unit using the optional venting kit.

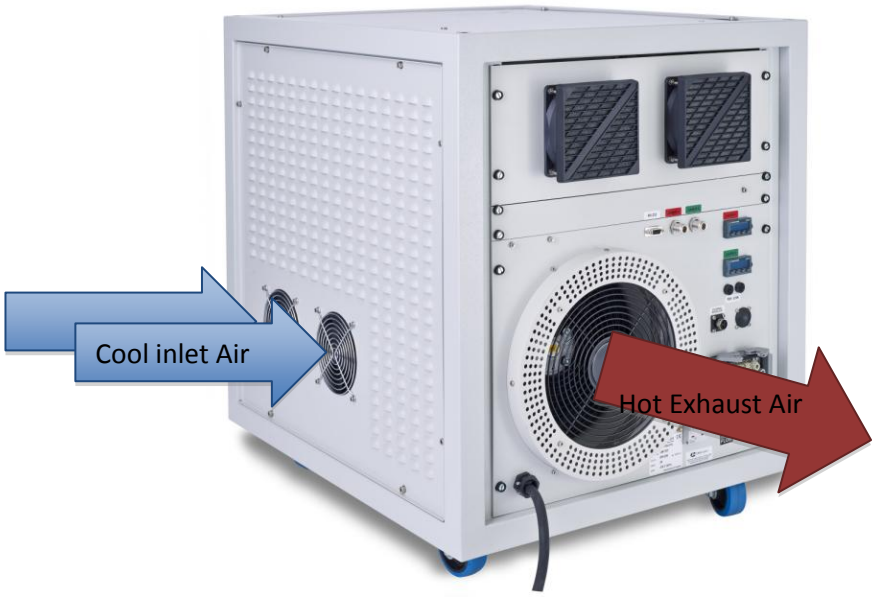


Figure 8: LDY-PIV PSU Air Flow

When using the system the chiller control temperature will be factory set. The control temperature will be noted in the test results at the rear of this manual.

In the unlikely event that the temperature seems to be rising above the set point, check that the power supply is positioned correctly to allow sufficient air flow through the chiller. If this fails to solve the problem it may be necessary to vent the hot exhaust air away from the chiller.

The chiller exhaust port is supplied with a cover. This has to be removed to allow the fitment of the venting pipe. Instructions on how to do this are included with the venting kit.

3.4 CONNECTING THE LASER HEAD TO THE PSU

Prior to proceeding with installation and connecting of the laser head with the PSU ensure that the guidelines given in Section 1.2 are understood and adhered to.

The laser head must be positioned onto a table or framework specified to hold the weight of the laser with ease. Care should be taken to ensure easy access to the laser head from all sides for future maintenance.

The power supply should be placed on a level surface with >500mm clearance to all sides for adequate cooling. The PSU castors (where fitted) should be locked after final positioning.

The laser head conduit is terminated with electrical connections and water connections. These are colour coded and where possible pin protected to ensure they can only be fitted to the correct connector in the correct orientation. Care must still be taken to ensure the cables from the laser head and the mains connection are correctly attached and connected before powering up the laser system.

CAUTION: RISK OF DAMAGE

PLEASE ENSURE THAT THE ELECTRICAL AND WATER CONNECTORS FOR LASER 1 AND LASER 2 ARE CONNECTED CORRECTLY TO THE CORRESPONDING CONNECTORS. LASER 1 CONNECTORS ARE COLOUR CODED AS RED AND LASER 2 CONNECTORS ARE COLOUR CODED AS GREEN.

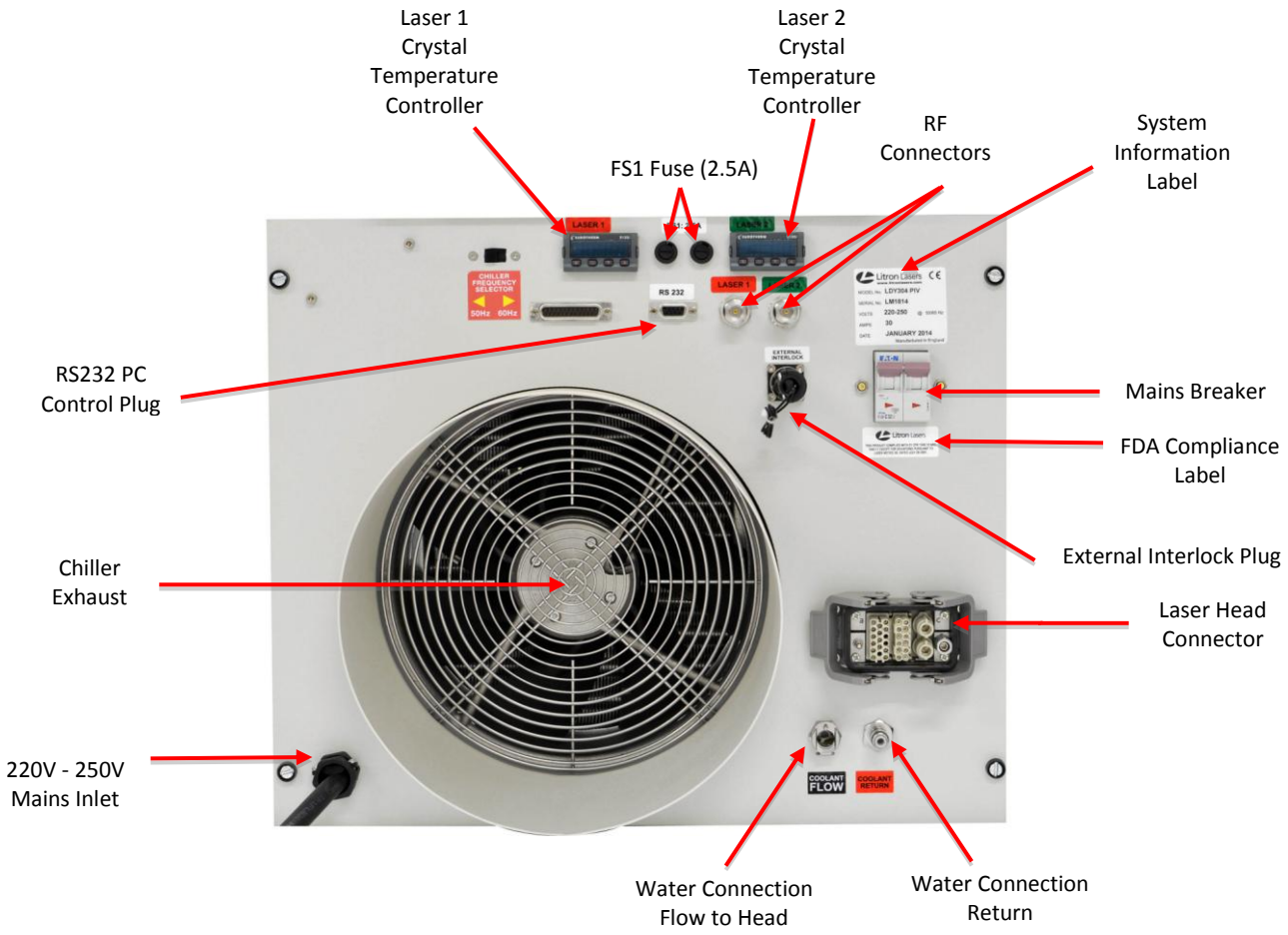


Figure 9: LDY-PIV Rear Connections

3.5 MAINS ELECTRICAL CONNECTIONS

The mains cable fitted to the system complies with the latest IEC AC Wiring colour codes.

Table 5:IEC Mains Wiring Colours

Function	Label	Colour, IEC	Colour, old IEC
Protective earth	PE	green-yellow	green-yellow
Neutral	N	blue	blue
Line, single phase	L	brown	brown or black
Line, 3-phase	L1	brown	brown or black
Line, 3-phase	L2	black	brown or black
Line, 3-phase	L3	grey	brown or black

Mains Service Requirements:

Laser Model Series	LDY30X-PIV
Voltage - Single Phase	220-250V
Current Rating (of Installation)	**32A**
Frequency	50Hz / 60Hz

If a suitable single phase supply is not available it is possible to connect to a line and neutral of a 3 phase supply. The latest IEC colour codes are detailed above

USA and European 3 phase colour codes are detailed below.

Country	L1	L2	L3	Neutral	Earth
North America	Black	Red	Blue	White	Green
North America (newer 277/480 installations)	Brown	Orange	Yellow	White	Green
UK until April 2006	Red	Yellow	Blue	Black	green/yellow striped (green on very old installations)
Europe (including UK) from April 2004	Brown	Black	Grey	Blue	green/yellow striped
Previous European (varies by country)	Brown or black	Black or brown	Black or brown	Blue	green/yellow striped
Europe, for bus bars	yellow	green	purple	–	–

NOTE: In The United States OR Japan to achieve the correct drive voltage for the power supply, the mains input should be wired between two of the phases, in the following way.

BROWN WIRE (LIVE) **TO L1**
BLUE WIRE (NEUTRAL) **TO L2**
GREEN & YELLOW WIRE (EARTH) **TO EARTH**

Connect the main conduit connectors from the laser head onto the correct sockets on the power supply back panel. Fit the laser head water pipes. Fit the external interlock override plug.

NOTE: BEFORE SWITCHING THE SYSTEM ON CHECK THE POLARITY AND VOLTAGE OF THE MAINS SUPPLY!

Turn the main breaker on the rear of the power supply rack, and then rotate the emergency stop control on the power supply front panel to turn power onto the laser system. At this point the harmonic generator ovens will become active.

When switching the laser on from cold, allow at least 10-15 minutes for the harmonic generators to achieve the correct operating temperature, and for the laser system to stabilise.

CAUTION: RISK OF DAMAGE

WHEN SWITCHING THE LASER ON FROM COLD ALLOW AT LEAST 15 MINUTES FOR THE HARMONIC GENERATORS TO ACHIEVE THE CORRECT OPERATING TEMPERATURE.

3.6 FILLING THE COOLING RESERVOIR

The cooling reservoir should only be filled with de-ionised(demineralised) water that has no contaminants. Using a coolant other than this could result in serious degradation of the laser output and damage to the system.

3.6.1 De-ionised Water Specification:

CAUTION: RISK OF DAMAGE
DO NOT USE 'DISTILLED' WATER IN THE LASER SYSTEM – UNWARRANTED DAMAGE WILL OCCUR.
ENSURE THE CORRECT SPECIFICATION COOLING WATER IS USED.

Water Specification

Water:	De-ionised/ Demineralised H_2O
Molecular weight (g/mol)	18.02 g/mol
Conductivity: (at 20˚C)	<20µS/cm
CAS No.	7732-18-5
EC No	231-791-2

Cooler reservoir, umbilical and laser head capacity:
LDY-PIV ~ 6 Litres

Procedure
The chiller should only be filled with clean **de-ionised** water. A container of this water is supplied with the laser system.

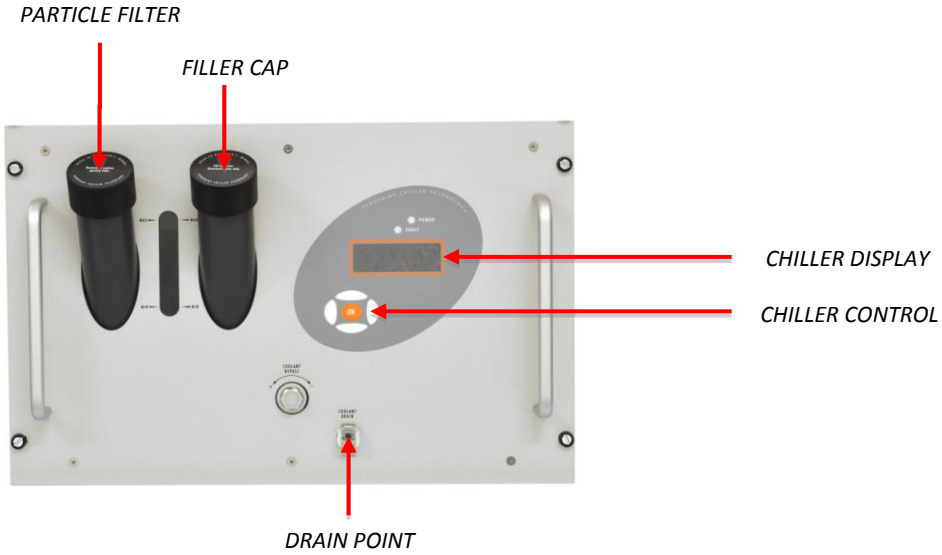


Figure 10: LDY-PIV Water Chiller Front Panel

The chiller function is controlled from the main laser system control panel, so none of the chiller controls need to be used to start the unit.

The chiller display will show the set and actual coolant temperature, flow rate, and load status. These can be accessed by pressing the UP/DOWN control button. Pressing the UP/DOWN control button once will display the current flow condition of the system this should be the same as detailed in the test results. The minimum flow is set at 1 l/min below this and a warning tone is sounded if the flow drops below this level. Pressing the LEFT/RIGHT button will cycle the display through a series of information screens, containing information on interlock status and capacity values.
The ADMINISTRATOR function is protected by a password and should not be used as the chiller operating parameters are factory set.

3.6.2 Auto Priming the Chiller

When filling the chiller unit with water for the first time, it will be necessary to bleed the pump.

Fill the chiller with clean de-ionised water, up to the top of the filler tube. Press the LEFT/RIGHT control button until the display reads 'PRESS OK TO PRIME'. Pressing 'OK' will start an automatic pump priming sequence which will take 2-3minutes to complete.

Once the prime sequence is completed, start the chiller (by operating the system), and wait for the flow interlock to clear. It may be necessary to repeat the bleed / fill process several times to get the correct flow condition.

CAUTION: RISK OF DAMAGE
DO NOT RUN THE CHILLER WITHOUT PERFORMING THE 'PRIME' FUNCTION.

3.7 EXTERNAL INTERLOCK CONNECTION

All the LDY-PIV series power supplies are fitted with an external interlock plug on the rear panel of the power supply.

This allows an external switch to be wired in series with the laser internal safety monitoring system. While this switch is closed the external interlock will allow the laser to operate normally. If this switch is opened the external interlock circuit will shut down the laser and remain latched until the switch is closed again.

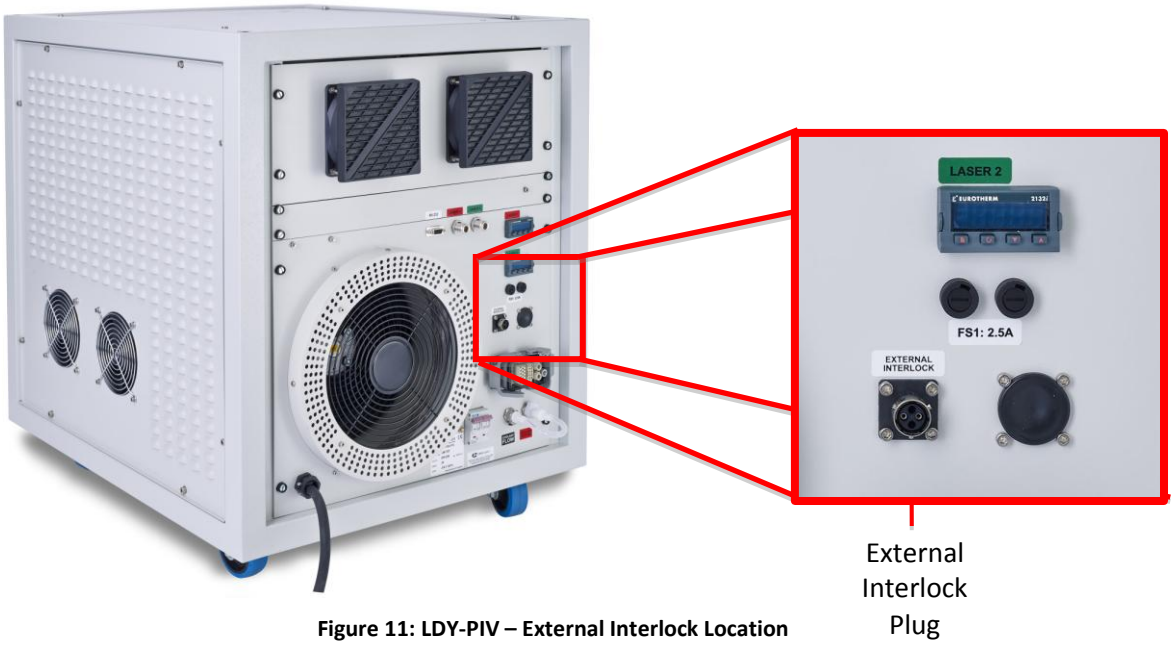


Figure 11: LDY-PIV – External Interlock Location

3.7.1 External Interlock Electrical Specification:

CAUTION: RISK OF DAMAGE
DO NOT APPLY AN EXTERNAL VOLTAGE TO THE EXTERNAL INTERLOCK CIRCUIT.

4. LASER OPERATION

Regardless of whether using the front panel interface, or the PC software control, the operation procedure for all LDY300-PIV models is the same. This procedure is described in the next section. The control functions are described in detail paying particular attention to functions that are unique to particular system types.

WARNING: LASER RADIATION

PROTECTIVE LASER GOGGLES MUST ALWAYS BE WORN WHEN OPERATING THE LASER. THE GOGGLES MUST PROTECT AGAINST ALL WAVELENGTHS THAT CAN BE EMITTED INCLUDING HARMONICS. THESE WAVELENGTHS ARE 1053nm, 808nm AND MAY INCLUDE DEPENDING UPON THE MODEL 527nm. ALWAYS AVOID DIRECT EYE OR SKIN CONTACT WITH ANY RADIATION BE IT LASER OR COLATERAL.

4.1 LASER SYSTEM CONTROL

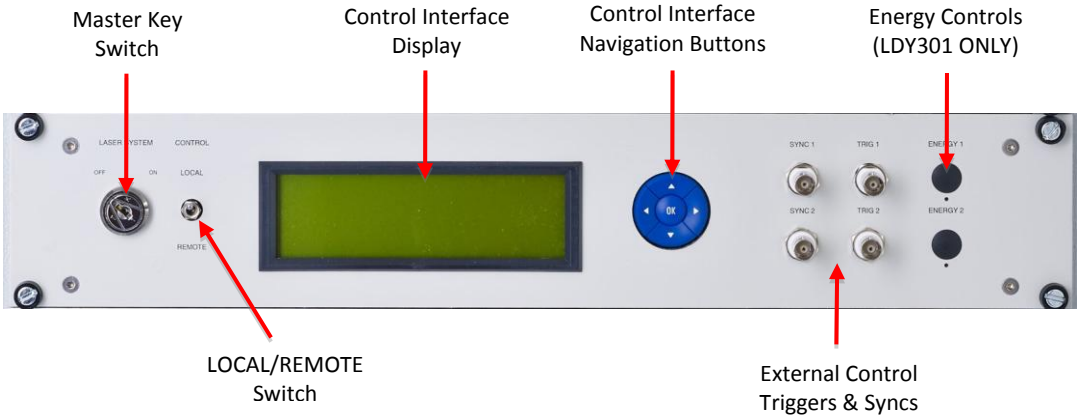


Figure 12: LDY-PIV System Control Panel

System Key Switch

Every Litron Lasers power supply is fitted with a system Key Switch. This switch enables the control functionality of the laser system.

LOCAL/REMOTE Switch

The LDY300-PIV laser systems are controlled via RS232. There are two methods of interfacing with the internal RS232 control system built into the system control tray:

Internal (LOCAL) Mode

Uses the LCD Display and directional control button interface on the front of the system tray.

External (REMOTE) Mode

Uses the PC based software Graphical User Interface (GUI) supplied on the DVD-ROM media supplied with this manual.

4.1.1 Initial Laser System Start-up

REMOVE THE BLANKING PLUG FITTED FOR SHIPPING.

The controls on the front of the laser power supply comprise the emergency stop button, the local remote switch, key switch, the laser control navigation buttons and display screen, and the laser energy controls, if fitted.

Turn on the system by rotating the emergency stop button so that it clicks in the out position, and turn the key switch to ON.

When using the controls on the power supply select LOCAL on the LOCAL/REMOTE selector switch. To operate the laser remotely from a PC via its RS232 input, select REMOTE.

NOTE: Turn the laser system OFF before changing selection.

CAUTION: RISK OF DAMAGE

AFTER INSTALLING THE LASER AND AFTER EVERY OCCASION WHEN THE LASER IS PHYSICALLY MOVED THE BASIC LASER HOLD OFF TEST MUST BE COMPLETED BEFORE RUNNING THE LASER UP TO FULL POWER. PLEASE SEE SECTION 6 FOR INSTRUCTIONS HOW TO COMPLETE THIS BASIC TEST.

4.1.2 Harmonic Generator Temperature Controllers

The harmonic generators have an up to temperature interlock incorporated to protect the system from operating until the correct harmonic generator (doubler) temperature has been achieved.

This is very important to stop the possibility of the laser being used in a condition where no 527nm light is being generated because of the low temperature of the crystal. If this is allowed to happen the high peak energy of the unconverted 1053nm light may damage the optical surfaces.

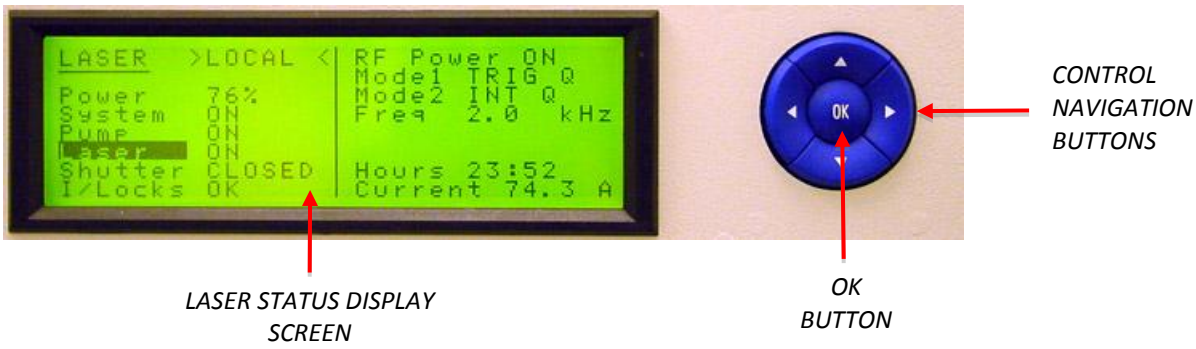
CAUTION: RISK OF DAMAGE

ALWAYS ALLOW ENOUGH TIME FOR THE HARMONIC CRYSTALS TO WARM UP AND STABILISE AT THE SET TEMPERATURE. IF THE CRYSTAL IS NOT THERMALLY TUNED THERE IS A RISK THAT NO 527nm LIGHT WILL BE GENERATED. THE RESULTING HIGH PEAK ENERGIES OF THE UNCONVERTED 1053nm LIGHT CAN DAMAGE THE INTRA-CAVITY OPTICAL SURFACES. DOING THIS WILL CAUSE UNWARRANTED DAMAGE TO THE LASER SYSTEM.

4.1.3 External Mode PC Software Control

The software installation and RS232 connection to the laser along with the software functions are described in the LDY300-PIV Software manual.

4.1.4 Internal Mode System Control



Use the arrow buttons to highlight the correct function, use the OK button to operate it, for example selecting System when the laser is OFF and pressing the OK button will turn the system ON. When ON pressing the OK button will turn the function OFF.

Shutter Open / Closed
When the laser is ON, opening the shutter will allow laser light to be emitted from the system.

Q-switch Controls

Selecting Q-switching Mode:
There are two (2) Q-switch operation modes:

1. INT Q: The internal timing clock will drive the Q-switch at the frequency set by the user (see below)
2. TRIG Q: The Q-switches are triggered externally via the TRIG BNC sockets on the front panel.

It is possible to change the Q-Switch mode for each laser by selecting either Mode 1 or Mode 2, and changing between INT Q and TRIG Q for each laser.

Selecting the Q-switch frequency for INT Q mode:
Use the navigation buttons to highlight Freq, select it by pressing OK then use the UP / DOWN buttons to change the value, (0-10 KHz), then press OK again to select the new value.

Interlock Status:
Selecting I/Locks and pressing the OK button will display the interlock status.

System Start-up:

When turning the system ON the following sequence should be used.

System ON

Pump ON
When Pump On is selected the chiller will start and coolant will flow round the laser head, and the coolant flow interlock will be defeated. If the pump is being started for the first time after an initial water fill, then the procedure for bleeding the chiller will have to be used to make sure that air is not trapped in the cooling system.

Laser ON
When Laser On is selected the laser diodes are switched on and the supplied drive current gradually increased to the simmer level.

NOTE: The Laser Power set level is customer variable. Normally the maximum available set level will be between 70% and 80%, and the minimum will be 5%. This will be detailed in the test results. Note: laser threshold ~ 20%

4.1.5 Laser Switch Off Sequence

When switching the laser off always do it in the following sequence, and ideally leave a few seconds between each operation. Ideally leave 2-3 minutes between Laser Off and Pump Off to disperse any residual heat.

CLOSE SHUTTER
LASER OFF
PUMP OFF
SYSTEM OFF
EMERGENCY STOP OFF

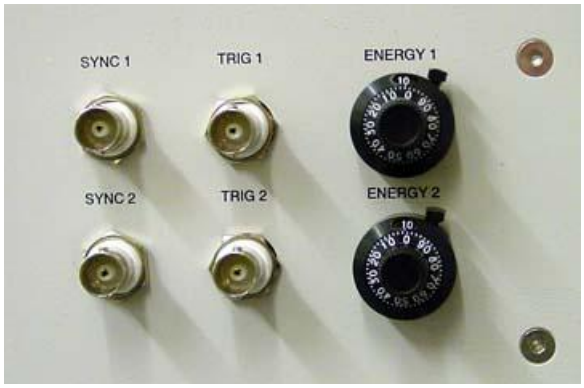
If the laser is to be transported anywhere then the complete system must be drained of water. Please refer to Draining the Chiller section. The laser head should be drained by blowing through the water pipes. Please refer to Draining the Laser Head.

4.1.6 Changing the laser output energy

When switching the laser on initially please note that the laser energy ramps up slowly over several seconds.

When switching the laser on you must check that the chiller reaches a stable temperature and that the water flow condition as detailed in the test results are met.

LDY301 Models Only: Energy Balancing Controls



NOTE:
The high energy models LDY302-PIV, LDY303-PIV & LDY304-PIV do not have the laser energy controls on the front panel.

On the low energy models, dials on the front panel act on the Q-Switches and allow the energies from each laser to be adjusted individually. Refer to the test results for the measured output energies for each laser. They are provided to allow the energy to be balanced between the two laser cavities.

CAUTION: RISK OF DAMAGE
THE ENERGY CONTROLS ON THE LDY301-PIV LASERS ARE ONLY FOR BALANCING THE OUTPUT ENERGY OF LASERS. DO NOT USE THESE TO CONTROL THE MASTER OUTPUT ENERGY OF THE LASER SYSTEM
THIS MUST BE DONE USING THE POWER CONTROL ON THE SYSTEM CONTROL INTERFACE.

LDY302-PIV / LDY303-PIV / LDY303HE-PIV / LDY304-PIV Models:
The laser output energy is controlled only by using the Power control via the front panel or PC interface.

4.2 PSU Front Panel TTL Controls

The trigger and sync signals for the laser are accessed from the PSU front panel. A typical layout is shown in Figure 20.

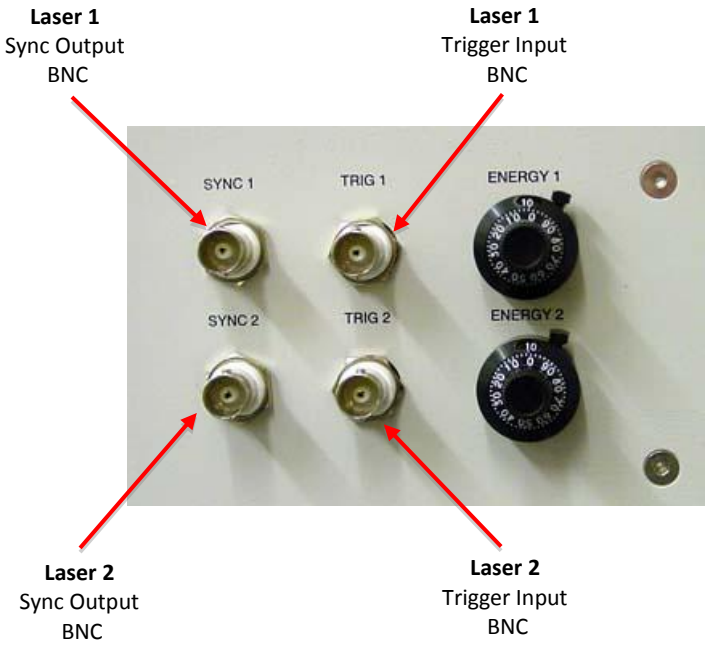


Figure 13:LDY-PIV External BNC Connections

Every LDY-PIV series power supply has 2 sets of BNC connectors (1 set for each laser) to allow full external control of the laser including the monitoring of the laser trigger signals.

CAUTION: RISK OF DAMAGE

NEVER APPLY A HIGH VOLTAGE EXTERNAL CURRENT SOURCE TO TRIGGER AND SYNC BNC CONNECTIONS. DOING THIS WILL CAUSE UNWARRANTED DAMAGE TO THE LASER SYSTEM CONTROL

CAUTION: RISK OF DAMAGE

INPUT TRIGGER SIGNAL MUST NOT BE 50Ω TERMINATED. USING A 50Ω TERMINATION WILL CAUSE THE TRIGGER TO WORK INTERMITENTLY AND MAY DAMAGE THE LASER SYSTEM CONTROL

SNYC 1 & 2 The Sync output signal is ~ 3-6µs before the output laser pulse.

Specification	Sync 1&2 Outputs		
Interface	50Ω BNC		
	Minimum	*Typical*	*Maximum*
Output voltage "high"	9V	10V	15V
Output voltage "low"	0V	0V	0.2V
Output current drive	-0.7mA		0.7mA
Pulse duration	8µs	12µs	15µ

TRIG 1 & 2 External Trigger TTL input for the Q-switch trigger circuit.

Specification	Trig 1&2 Inputs		
Interface	50Ω BNC		
	Minimum	*Recommended*	*Maximum*
Input voltage "high"	4.5V	5V	15V
Input voltage "low"	-1V	0V	0.5V
Input current sink	-0.7mA		12mA
Pulse duration	10µs	15µs	20µs
Trigger edge		rising	

4.2.1 Third Party PIV Laser System Interface

Most complete PIV laser systems will have a system timing controller as part of the system. This controller will manage the timing of all parts of the PIV system including cameras and the laser.

The output from this controller will typically have four (2) dedicated outputs to control the LDY PIV laser system.

The table below shows the correct connection for these outputs.

Table 6: External PIV Controller Output – Input Table

PIV Laser Controller Output	LDY-PIV Input	LDY-PIV Laser Mode
Q1	Laser 1 –Q-Switch Trigger	TRIG Q
Q2	Laser 2 –Q-Switch Trigger	TRIG Q

4.3 INTERLOCK DESCRIPTIONS

All Litron laser systems are equipped with a full suite of interlocks. The function of an interlock can be either to:

1 To shut the laser down when further operation in the current state may cause damage to the system.

OR

2 To prevent the system being operated in an unsafe state that could result in harm to the user.

The function detailed in point 1 also acts as a self-check during laser start up.

Latched Indication.

Some of the interlocks are latched so that if a transient fault occurs (such as an RF Driver Fault), the user can readily see the cause for the system shutdown. This is an important diagnostic tool. Clearing the latch requires the laser to be restarted. A full description of the interlocks follows. NOTE that the Interlock status will read OK if the fault has reset, please check the interlock screen if the laser will not start up correctly.

Interlock Status:

Selecting I/Locks and pressing the OK button will display the interlock status.

Laser Head

This interlock prevents the laser from working if the cover has been removed from the laser head.

WARNING: RISK OF ELECTROCUTION

NEVER OPERATE THE LASER WITH THE COVERS REMOVED FROM THE LASER HEAD AND INTERLOCKS DEFEATED. LETHAL VOLTAGES ARE PRESENT THAT MAY CAUSE DEATH OR SERIOUS INJURY

Shutter
The position of the shutter is monitored by the system control. Should the actual position of the shutter and the required position of the shutter not be in agreement then the interlock will be tripped.

Driver Temp
This interlock is not active on the LDY Laser system

PSU Temp
This interlock monitors the diode driver heat sink temperature. If this interlock is activated it may indicate that the cooling air supply to the heat sink has failed. Check to make sure that the cabinet cooling fans are running and that the filters are not blocked.

The interlock triggers if the heat sink temperature rises above 50°C the system will shut down. This interlock uses a thermal switch that will take several minutes to cool down and switch back to a closed position. Please allow approximately 10 minutes after solving the problem before attempting to re-start the laser.

External/HG
The external interlock is accessed by a plug and socket on the power supply back panel. It allows the system to be interlocked to an external input such as a door switch.

CAUTION:
NEVER APPLY AN EXTERNAL VOLTAGE TO THE EXTERNAL INTERLOCK CONNECTION. DOING THIS WILL CAUSE UNWARRANTED DAMAGE TO THE LASER SYSTEM CONTROL

1. **External:** The external interlock is accessed by a plug and socket on the power supply back panel. It allows the system to be interlocked to an external input such as a door switch. **Never apply an external voltage to this connection, or connect to ground!**

2. **HG:** The harmonic generator (doubler) temperature controllers have an up to temperature interlock, this is incorporated into the External interlock circuit. Please refer to harmonic generator temperature controls section for more information.

RF Driver 1 & 2: Each of these interlocks monitors 3 conditions on its own laser. These conditions are as follows:

1. Over temperature of the RF drivers. This may be caused by an interruption to the cooling water supply to the driver.

2. Over temperature of the Q-switch (Modulator) on the laser head. This can be caused by an interruption of the cooling water flow.

3. Incorrect VSWR condition. This can be caused by a disconnection or mismatch of the RF feed to the Q-Switch (Modulator). This condition can sometimes cause an interlock condition when the system is first switched on, or when the system has been switched off and back on again. Pressing Laser On will clear the condition. Otherwise check for loose RF supply cables, on the power supply back panel or on the Q-switch (Modulator) connections at the laser head.

Water temp: The chiller has a defined temperature window of operation. The upper and lower limits are set at 16°C and 30°C. When these limits have been exceeded an interlock condition will occur. There will also be an audible alarm and a warning will flash up on the chiller control panel LCD. This is normal when the chiller is first switched on in cold ambient conditions as the water temp is likely to be below the lower limit. As the water heats up the alarm will change from a constant tone to intermittent then off. If the ambient temperature is very high it may be that the chiller will not be able to maintain the set control temp. The coolant temperature will then rise until the upper limit is reached, and again an audible alarm will be heard. Please refer to the section concerning chiller airflow and venting of hot air.

Water level: If the water level drops in the chiller for any reason an audible alarm will be heard and a warning will flash up on the chiller control panel LCD. A water level interlock condition will occur. Check for leaks and top up the chiller to the correct level.

Water Flow: As with the temperature the chiller is set to operate within a set water flow range. This will have a minimum value set to ~ 1L/min below the measured flow rate as detailed in the test results. The upper value is set as the standard default value of the chiller. If the flow rate falls below the set minimum value an audible tone will be heard and a warning will flash up on the chiller control panel LCD. Check for loose or twisted laser head water pipes, then if these are satisfactory, check and replace the filter element. Refer to Particle filter replacement.

4.4 Harmonic Generator Temperature Controllers

The temperature controllers for the 527nm harmonic generation crystals and housing are fitted to the rear of the power supply and do not need to be adjusted as part of the everyday operation of the laser system.

The controllers are set to enable certain interlocks depending on the status of the laser. The information below explains their operation at various stages in the start-up and warm up period of the laser system.

The set temperature of the harmonic generator (doubler) crystal is factory set at a temperature of 70°C. The up to temperature interlock is set at ~3° below this. Until this temperature is achieved it is not possible to turn the laser on.

The interlock is linked into the External interlock circuit, so the External interlock will not be closed until the correct temperature is achieved.

4.5 Pulsed Monitor Diode

On all current LDY-PIV series lasers a fast rise time photo diode is incorporated to monitor the output pulses of the laser. The diode is mounted to monitor light scattered off the final dichroic mirror.

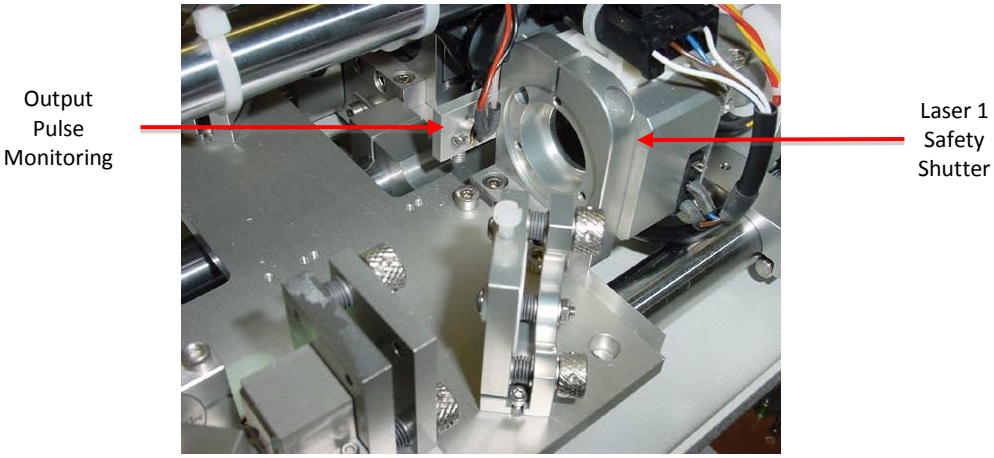


Figure 14: LDY-PIV External BNC Connections

The signal from the diode is taken to a BNC socket on the laser head service plate next to the conduit. This signal can be viewed on a suitable oscilloscope to give a very accurate signal of when the output pulses occur relative to the TRIG IN signals.

Figure 15: LDY-PIV Pulse Monitor - BNC Connection

Some typical scope images are included on the following page.

Diode Output Examples

Please note:

1. *Even though the output pulse energies are the same, the pulse signal from Laser 2 will be smaller. This is due to the different polarization of the beam from Laser 2.*
2. *The monitor diode is meant only as a device to allow accurate measurement of the pulse separation of the laser beams. It is not intended as a device to allow energy measurement*

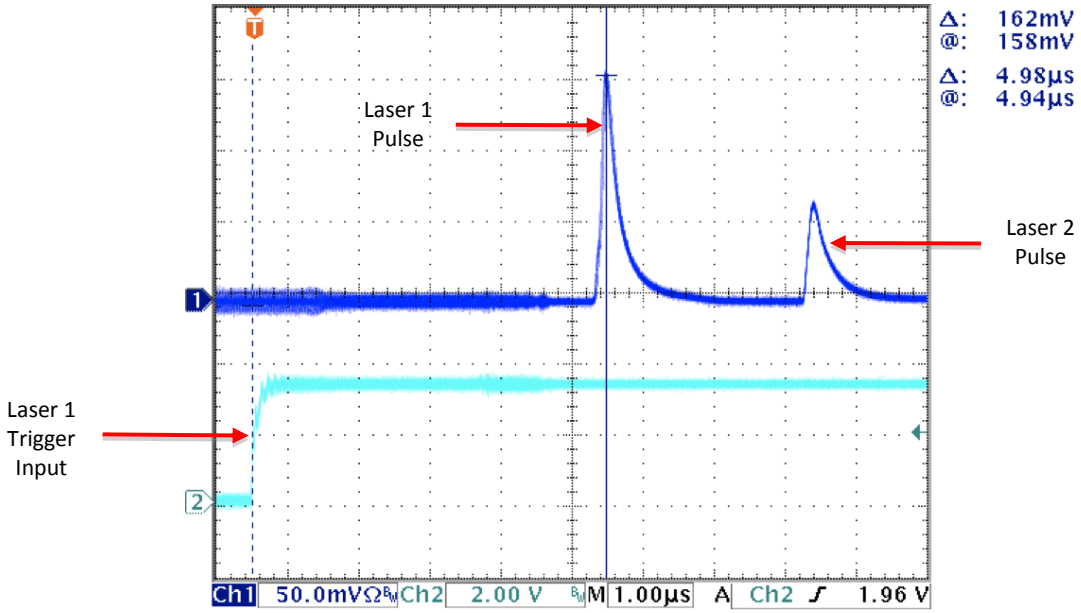


Figure 16: LDY-PIV Pulse Monitor – Example Trace 5µs Delay

The trace above shows a typical output from the monitor diode. Laser 1 is being externally triggered via the TRIG Q input. Laser 2 is being triggered with a delayed signal via the TRIG Q input. The output from the diode is being 50Ω terminated at the scope. (300MHz Tektronix).

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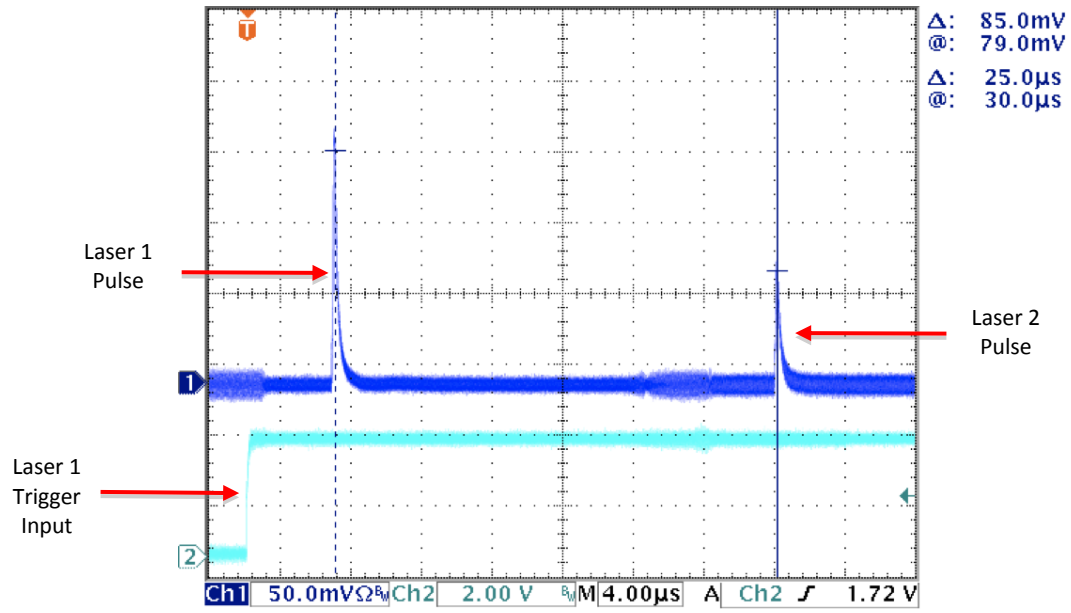


Figure 17: LDY-PIV Pulse Monitor – Example Trace 25µs Delay

This trace shows the pulses with a 25µs delay. The diode input to the scope is 50Ω terminated.

5. LASER SYSTEM OPTIONS

The LDY-PIV Series lasers are fully integrated dual cavity lasers for PIV and imaging applications.

There are currently no standard options that can be fitted to this laser system.

6. MAINTENANCE & CARE

There is very little routine maintenance that should be required with the LDY-PIV series of laser system. The chiller particle filter and de-ionised water should be replaced every 6 months to assure the on-going performance of the laser system. Starting the pump and running for a few minutes once a week is good practise to avoid water contamination.

6.1 CONSUMABLE PARTS REQUIRED

6.1.1 Particle Filter

No deioniser cartridge is fitted to the LDY power supplies.

Laser System:	Quantity Required	Litron Part Number:
LDY300 Series	1	LP02053

6.1.2 De-ionised Water

ENSURE THE CORRECT SPECIFICATION OF COOLING WATER IS USED:

Water Specification:

Water:	De-ionised H2O
Molecular weight (g/mol)	18.02 g/mol
Conductivity: (at 20˚C)	<20µS/cm
CAS No.	7732-18-5
EC No	231-791-2

Cooler reservoir, umbilical and laser head capacity:
LDY-PIV: 6 Litres

6.2 End User – Q-switch Check

This is a simple procedure that MUST be completed before switching the laser to full power after initial shipping to your site or if the laser is physically relocated from the initial installation position to another location. This procedure can prevent serious damage to the laser system.

Frequency:	Every time the laser is moved from one location to another.
Skill Required:	Level 1 - End User – using this manual
Safety:	Laser Safety Goggles.
Tools Required:	Piece of White Card / Laser Phosphor / Ceramic Plate
Parts:	None

WARNING: LASER RADIATION

PROTECTIVE LASER GOGGLES MUST ALWAYS BE WORN WHEN OPERATING THE LASER. THE GOGGLES MUST PROTECT AGAINST ALL WAVELENGTHS THAT CAN BE EMITTED INCLUDING HARMONICS. THESE WAVELENGTHS ARE 1053nm AND 527nm. ALWAYS AVOID DIRECT EYE OR SKIN CONTACT WITH ANY RADIATION BE IT LASER OR COLATERAL.

CAUTION: DAMAGE TO INTERNAL PARTS

FAILURE TO COMPLETE THIS PROCEDURE AND ACT ON THE RESULT CAN RESULT IN DAMAGE TO THE INTERNAL PARTS OF THE LASER.

Procedure:

1. Start up the laser to the point where the pump is running and the **System** is **ON.**
2. Ensure the chiller and harmonic generators are at the correct set temperatures.
3. **DO NOT OPEN THE SHUTTERS**
4. Using the front panel control –switch the **MODE** for both lasers to **TRIG-Q**
5. **DO NOT CONNECT ANY SIGNAL TO THE TRIG-Q BNC CONNECTORS**
6. Set the **SHUTTER** to **OPEN**
7. Place the piece of white card /laser phosphor in front of the laser output port.
8. Look carefully at the white card / laser phosphor to determine if there is any green laser light being emitted by the laser. (This is best done in a darkened room.)
9. **If any green laser light is observed on the white card DO NOT start the laser until the Q-switch adjustment procedure has been completed by a competent engineer.**

6.3 REPLACING THE CHILLER FILTER AND COOLING WATER

The de-ionised water quality in the laser system is critical for long term reliability and longevity of the laser system. Please complete this procedure as per the recommendation below to assure the reliability and long life of the laser system.

Frequency:	Every 6 Months, or after storage more than 3 months.
Skill Required:	Level 1 - End User – using this manual
Safety:	Disconnect the PSU from the mains supply. No personal protective equipment is recommended.
Tools Required:	Transportation Water Pipe (supplied) Bicycle Pump (see below)
Parts:	Water Filter (See Parts List) De-ionised water

WARNING: RISK OF ELECTROCUTION

Turn off the mains supply at the wall and remove the plug and lead from the wall and PSU.

CAUTION: DAMAGE TO INTERNAL PARTS

Care should be taken during this procedure to ensure that no pipes or connections are disturbed or damaged.

6.3.1 LDY Series – Draining the Chiller

The chiller will need to be drained if the system is to be moved or stored.

1. Isolate the power supply from the mains.

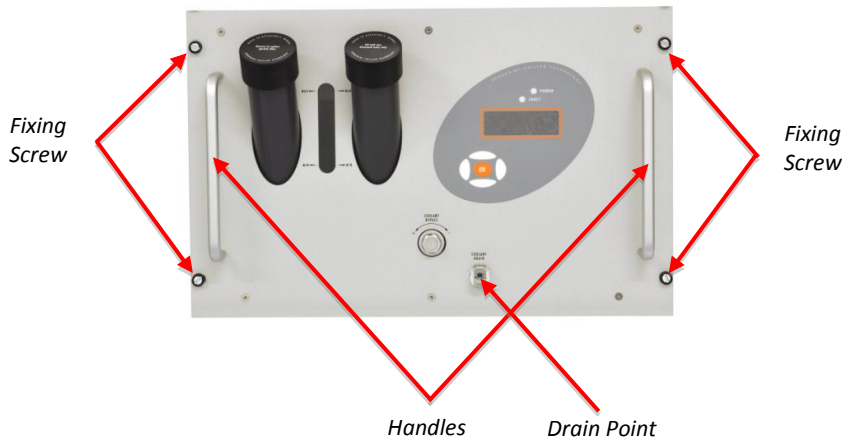


Figure 18: LDY-PIV Chiller Fixing Screws Location

2. Remove the Filler cap to allow air to enter the reservoir.

3. The drain point is located on the front panel as arrowed.

4. A suitable tray should be used to catch the drained water.

5. Insert one of the transportation water pipes supplied with the Laser system into the drain point connector. The reservoir will now drain into the drip tray below.

Figure 19: LDY-PIV Chiller Drain Plug Location

6. If the laser system is to be shipped to a different location or if it is to be laid up for any long periods, it is very important to drain the laser head.

6.3.2 Draining the Laser Head.

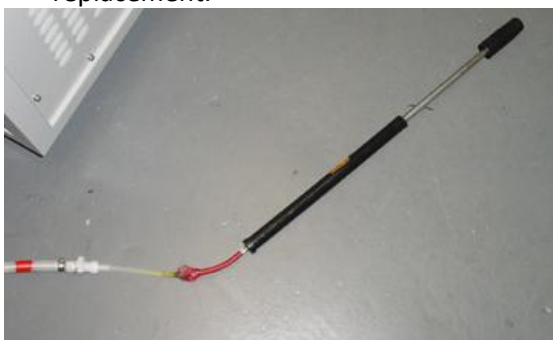
The laser head must be drained of all coolant if it is to be shipped, or if there is any risk of it being subjected to sub zero temperatures. If the coolant in the laser head is allowed to freeze, severe damage may be caused to the laser rods.

After completing steps above go round to the rear of the power supply and identify the coolant flow pipe to the laser head. This will be marked with a piece of coloured tape or a label on the back panel where it connects. Disconnect it. Both the head connections are self seal so a suitable connector must be inserted into the mating connector on the pipe to open it. These are supplied with the system.

1. Use the Bicycle pump to force all the water back into the chiller where it will drain out of the drain hole (see photograph).

2. If the laser is to be shipped, disconnect the coolant return pipe from the back of the power supply unit and tie the connectors inside a plastic bag to protect them.

3. If the water and filter are to be changed please proceed to the following section. Particle filter replacement.



6.3.3 Particle Filter Replacement

The filter removes any particles from the water (coolant). This protects the Laser system from the particles that can build up over time. The filter should be changed every 500 hours run time of the chiller unit or 6 months. The water (coolant) should be checked at regular intervals (every 6 months) to make sure it is clean. The water (coolant) reservoir should be drained down and cleaned out every 12 months. The drain point on the chiller is on the front panel (6.3.1). Rinse the coolant circuit out with new water (coolant) and run the chiller for 15 minutes, drain and repeat 3 times. Check the flow rates and pressure of the coolant during the rinsing process.
To change the filter, un-screw the filter cap on the front panel. Un-screw the cap but do not take off the tube. Let the air fill the tube for 1 minute to avoid water (coolant) dripping from the filter tube. After 1 minute remove the cap from the tube and pull out the old filter and push on the new filter.

Refill the water (coolant) with the specified coolant for the chiller. Use only clean, new coolant **(never fill the coolant reservoir with used coolant).**

Unscrew the filler cap marked particle filter. Allow air to enter before removing the cap completely. This reduces pressure and allows the cap to be removed without spillage.

Figure 20: Filter Position

Removing the cap completely reveals the filter element.

Figure 21a: Filter Cap

The filter element is a push fit into the cap. Ensure the replacement element is seated firmly inside the cap before screwing the assembly back into the chiller.

Figure 21b: Filter Element

6.4 Optical Assemblies Care and Maintenance

During the lifetime of the laser it may be necessary for certain parts of the laser's optical assemblies to be adjusted or tuned.

This typically results from the laser system being moved from one location to another on a regular basis.

The diagram below details the key components that will be covered in the following sections. With the exception of the 527nm steering mirrors in the beam combination section the major components are the same for both Laser 1 and Laser 2.

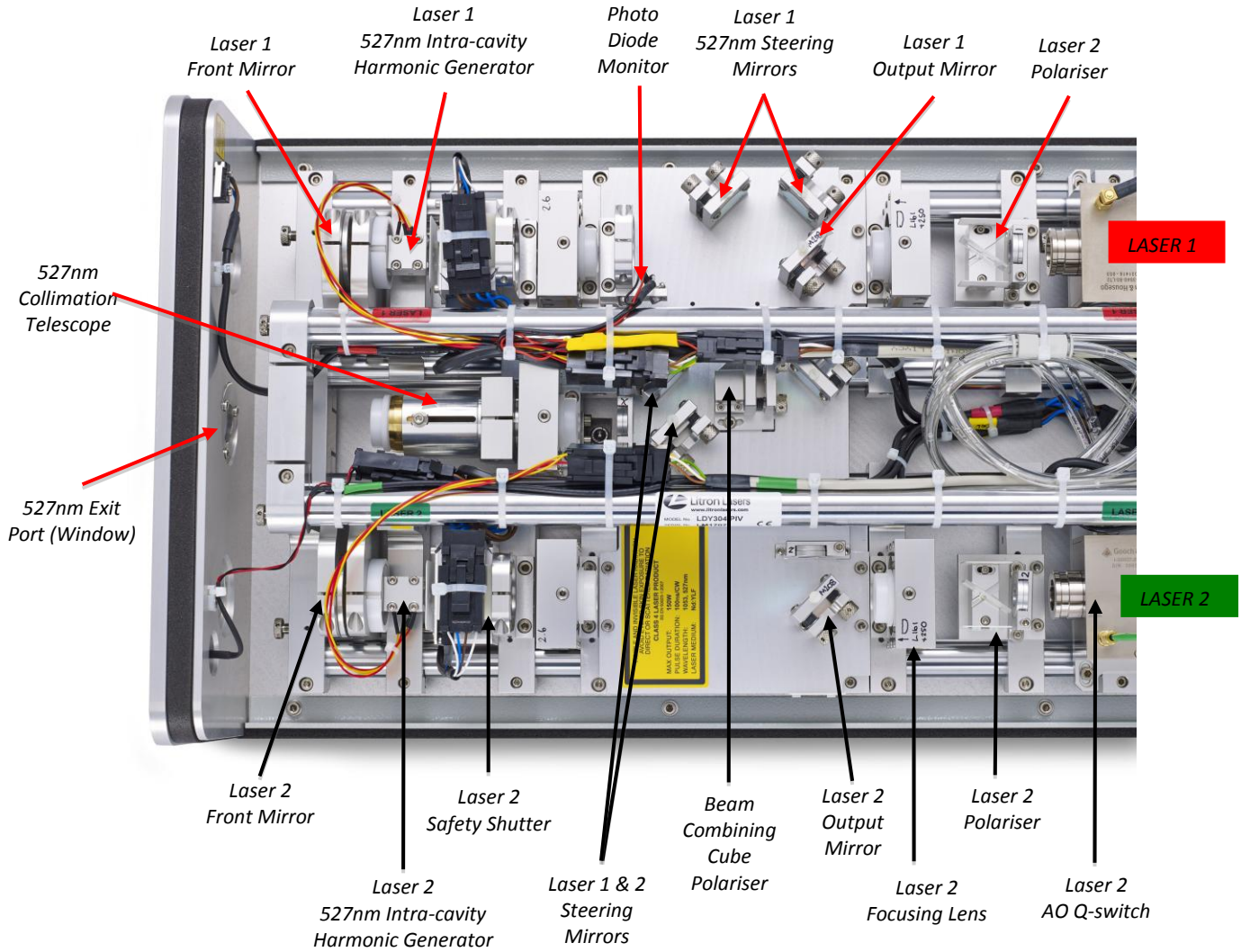


Figure 20: LDY-PIV Optical Layout

6.5 Laser Beam Overlap Alignment

Frequency:	As Required
Skill Required:	Level 2 - Suitably trained, experienced and competent laser engineer
Safety:	Laser Radiation – Laser Safety Eyewear.
	Latex Gloves
Tools Required:	Metric Allen Key Set
	2 x Laser Target Material (Ceramic Plate with Cross Hairs)
Parts:	Non Required

WARNING: LASER RADIATION

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WARNING: RISK OF ELECTROCUTION

IT IS NOT NECESSARY TO OPEN ANY COVERS THAT REVEAL HIGH VOLATGES DURING THIS PROCEDURE. DOING SO MAY RESULT IN ELECTROCUTION.

CAUTION: RISK OF DAMAGE TO INTERNAL PARTS

1. Do not undertake this procedure unless you are competent to do so.
2. NEVER TURN THE LASER ENERGY ON AND OFF BY BLOCKING THE CAVITY.
3. ALWAYS USE THE LASER SHUTTERS. FAILURE TO DO THIS MAY RESULT IN OPTICAL DAMAGE
4. Do not touch any optical component directly as this may contaminate /damage the surface.
5. Ensure that all covers and protective covers are replaced correctly after completion.

6.5.1 527nm Beam Combination

The LDY-PIV laser systems use twin 1053nm oscillators with intra-cavity doubler assemblies to produce two independent 527nm laser beams. These two beams from individual lasers are steered using 527nm high reflectivity mirrors and combined using a cube polariser. The turning mirrors are also anti-reflection coated at 1053nm to allow the main pump resonator to continue working. Each of these various mirrors are mounted on a fully adjustable mount, to allow accurate co-linear alignment of the two beams. The beam steering mirrors and mixing polariser are mounted on a common base plate which is in turn mounted onto the thermally stable Invar optical rail.

As standard both 527nm beams are vertically polarised. The beam from Laser 2 is passed through a half wave plate to rotate its polarisation to horizontal. It will then be reflected off the steering mirror and passes through the beam combining polariser with minimal loss. The beam from Laser 1 remains vertical and is reflected off the beam combining polariser, again with minimal loss.

Because there is always a slight loss through the beam combining and steering polarisers, suitable ceramic beam dumps are used to catch the un-combined energy.

The beams from the 2 laser resonators will be aligned to be co-linear at the factory.

6.5.2 Initial Preparation:

Please familiarise yourself completely with the layout and the relevant adjustment points that will be used to adjust the near and far field beam overlap.

Near Field: This is a point typically ~ 20 to 30 cm from the beam combination polariser.

Far Field: This is a point typically >2m and ideally 3m from the output of the laser head.

The beam combination optics are all mounted on to a single aluminium optical baseplate that is in turn mounted on the Invar optical rail system for enhanced stability irrespective of changes in the ambient temperature.

The 527nm mirror arrangement in the LDY-PIV laser systems ensures an approximately equal beam path length for the two 527nm (Green) laser beams before they are combined. This ensures the light sheets generated by Laser 1 & Laser 2 have as similar beam properties as possible.

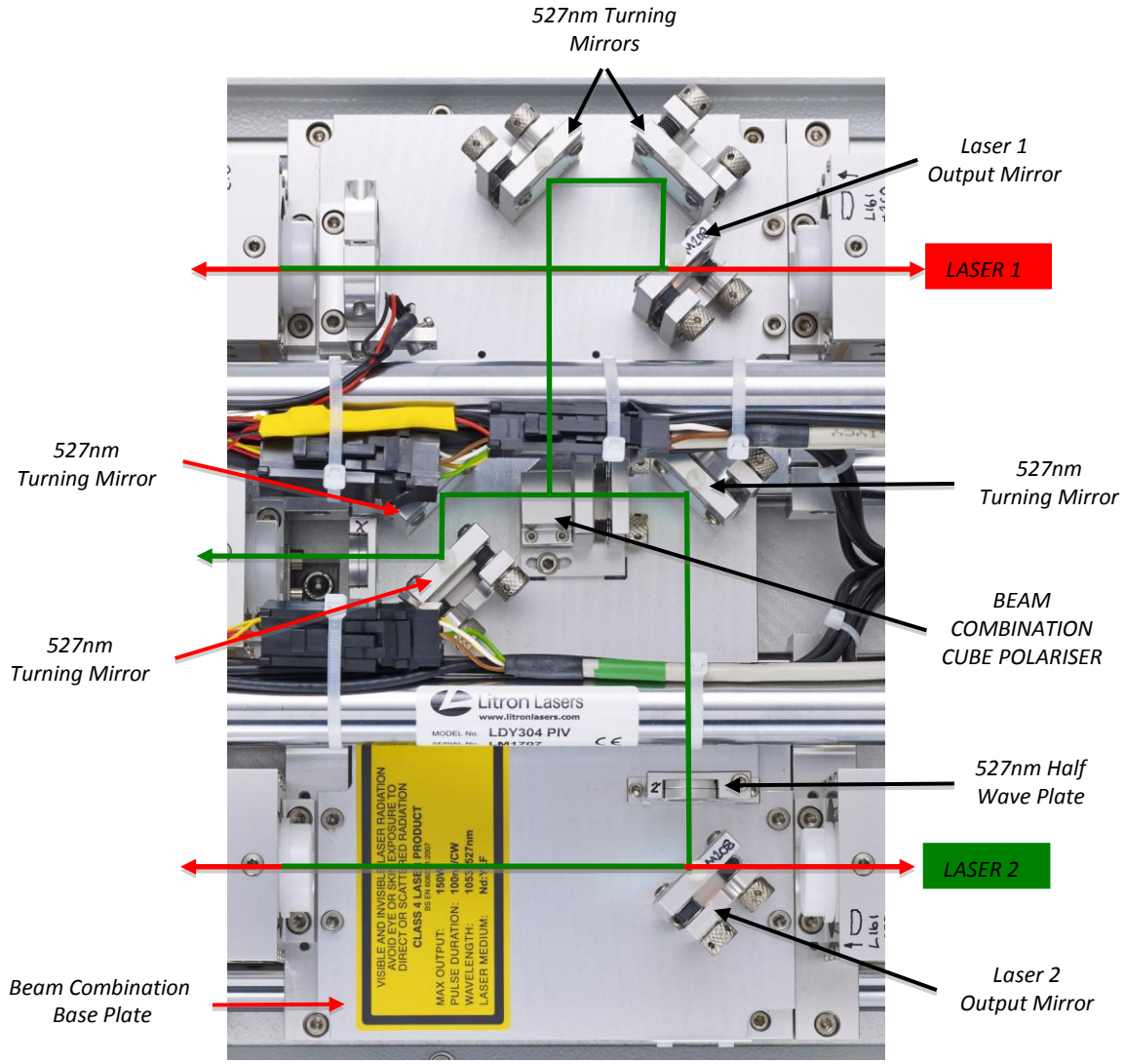

Figure 21: LDY-PIV Beam Combination Layout

6.5.3 Mirror Mount Adjustment:

The mirror mounts used for steering the 527nm beams have two (2) adjusters, these can be used to change the angle of the mirror relative to the optical axis. Changing the angle has the affect of adjusting the beam position in either the horizontal or vertical axis, relative to the central optical axis.

The figures below indicate the correct adjusters to be used for tuning the beam combination overlap. No other adjustment screws must be touched.

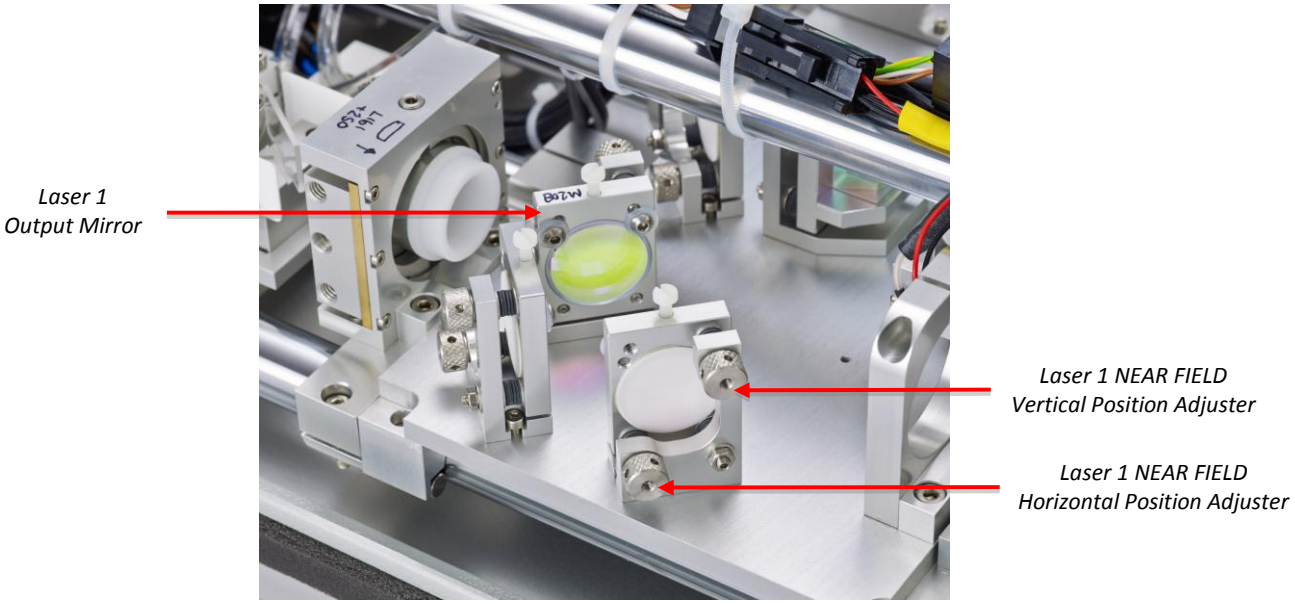

Figure 22: LDY-PIV Laser 1 NEAR FIELD Adjustment

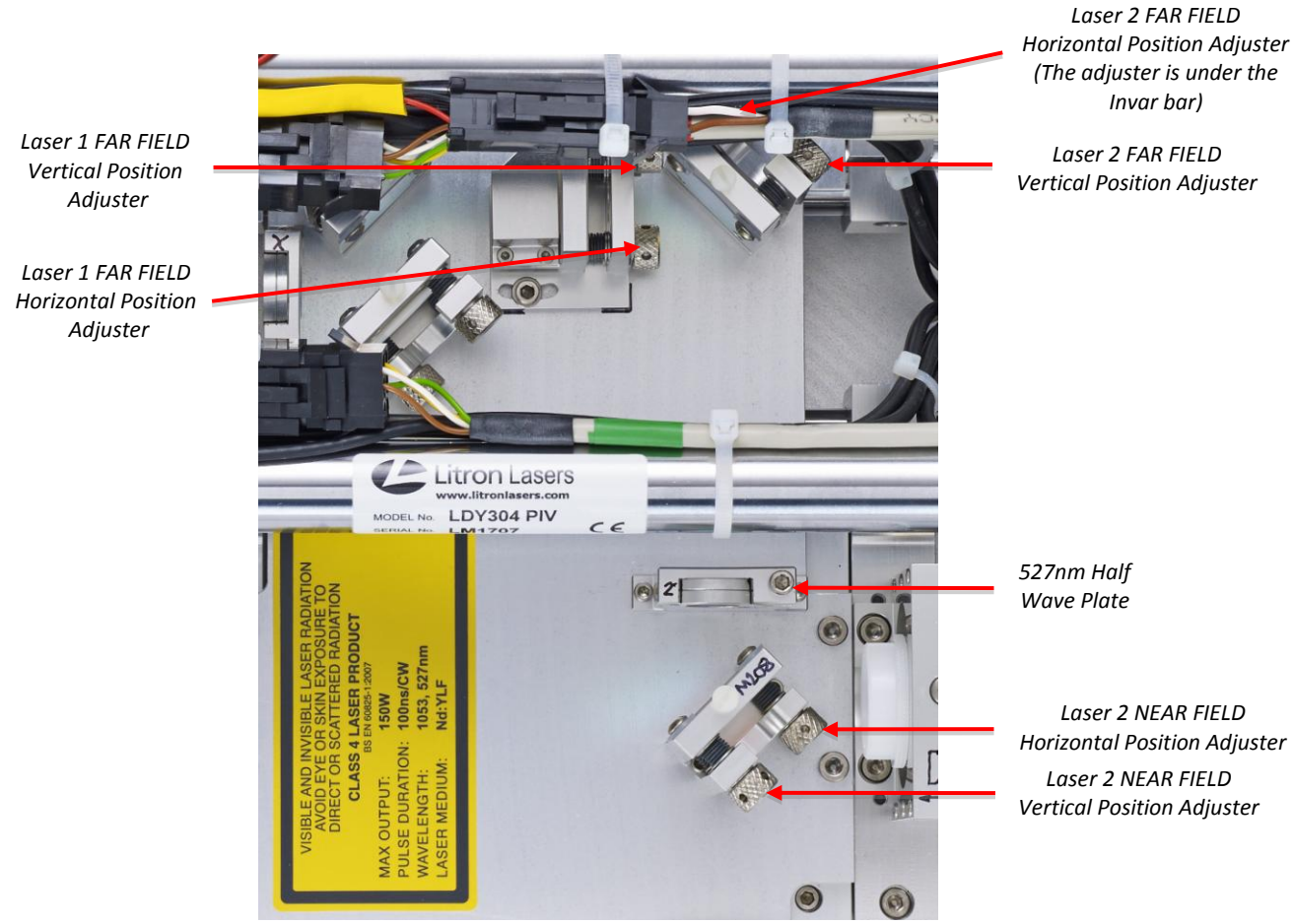

Figure 23: LDY-PIV Far Field Combination Adjusters

6.5.4 Near and Far Field Alignment Procedure:

During these adjustments please be wary of the beam path around the combining optics. It is very easy to block the beam path and cause damage to optics or injury.

Fit the ceramic aperture into the output orifice of the laser. This will have a diameter of ~ 7.0mm. This is the near field alignment point.

The beam from Laser 2 is now used as the datum point, and Laser 1 will now be adjusted onto it.

Switch laser 1 to TRIG-Q without applying an external trigger, make sure laser 2 is switched to INT trigger, and open the laser shutters. The beam from laser 2 should pass exactly through the near field aperture. When using suitable 527nm laser goggles it will be possible to see if the beam is passing through the aperture centrally.

If the beam from laser 2 is not passing through the near field aperture centrally, adjust *Laser 2 Near Field* in the horizontal and vertical plane until the beam passes centrally through the aperture.

Now mark the position of the beam on a ceramic plate as far from the laser as possible (2-3m).

Now switch laser 2 to TRIG-Q without applying an external trigger, and change laser 1 to INT trigger. Open the shutters.

Check that the beam from laser 1 is passing through the near field aperture, and hitting the far field alignment mark.

It is unlikely that the beam overlap will be far off so it is advisable to adjust the laser 1 beam for the far field overlap only on Laser 1 Far Field adjusters.

The far field beam overlap is achieved by adjusting Laser 1 Far Field in the horizontal and vertical plane.

In the unlikely event that the near field alignment is out, then the *LASER 1 NEAR FIELD ADJUSTER* will have to be adjusted.

Adjust the mirror in the vertical and horizontal planes until the beam is passing centrally through the near field aperture, then re-check the far field overlap.

If the beam overlap is a long way off then the above steps will have to be repeated several times.

CAUTION: RISK OF DAMAGE TO INTERNAL PARTS

Care must be exercised when making this adjustment as it is possible to move the beam a long way, allowing the beam to clip the edge of the harmonic crystal and dichroic mirrors, causing damage and further misalignment.

6.6 Cavity Adjustment:

Frequency:	As Required
Skill Required:	Level 2 - Suitably trained, experienced and competent laser engineer
Safety:	Laser Radiation – Laser Safety Eyewear.
	Latex Gloves – Do not touch any optical surfaces.
Tools Required:	Calibrated Power Meter
Parts:	Non Required

WARNING: LASER RADIATION

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WARNING: RISK OF ELECTROCUTION

IT IS NOT NECESSARY TO OPEN ANY COVERS THAT REVEAL HIGH VOLATGES DURING THIS PROCEDURE. DOING SO MAY RESULT IN ELECTROCUTION.

CAUTION: RISK OF DAMAGE TO INTERNAL PARTS

1. Do not undertake this procedure unless you are competent to do so.
2. NEVER TURN THE LASER ENERGY ON AND OFF BY BLOCKING THE CAVITY.
3. ALWAYS USE THE LASER SHUTTERS. FAILURE TO DO THIS MAY RESULT IN OPTICAL DAMAGE
4. Do not touch any optical component directly as this may contaminate /damage the surface.
5. Ensure that all covers and protective covers are replaced correctly after completion.

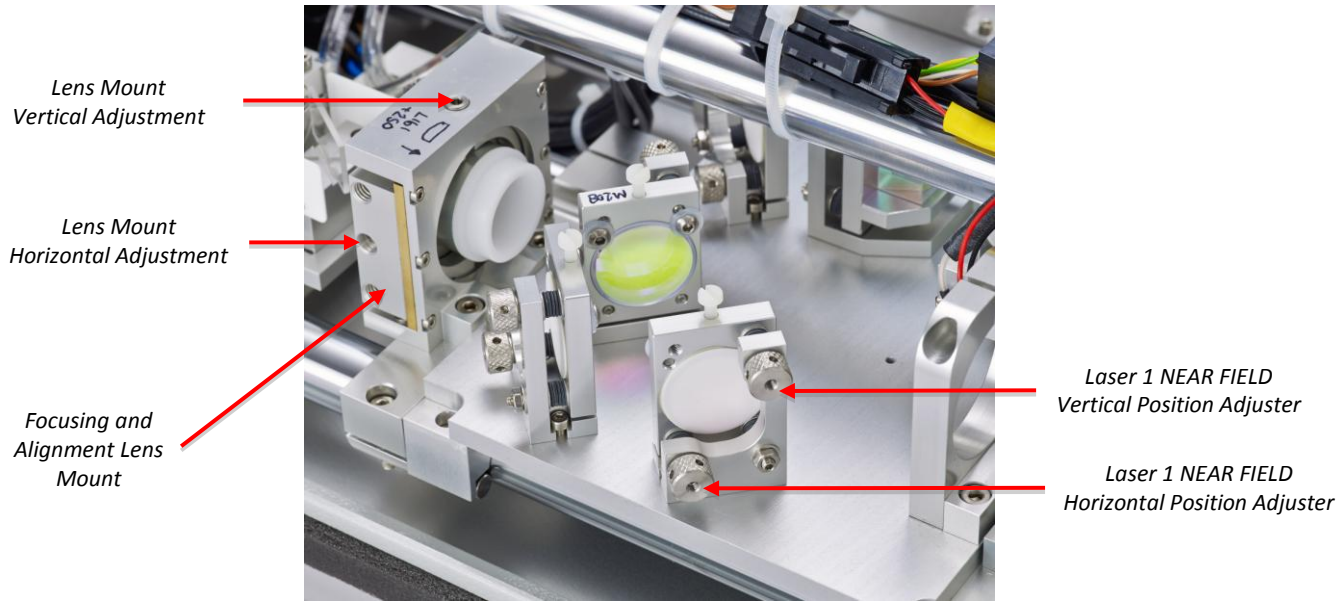
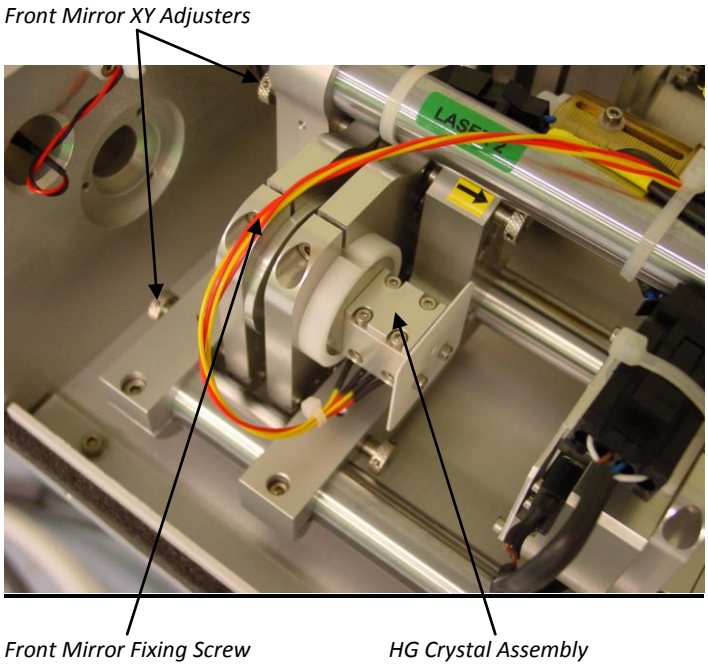


Figure 24: LDY-PIV Lens Mount Adjustment

Before adjusting the cavity ensure the Q-switch is holding off correctly and that a power meter is correctly set up to monitor the energy.

The cavity can optimised for maximum energy by using the intra-cavity lens. This is marked L161 in the image above. The lens mount can be adjusted horizontally and vertically while monitoring the output with a suitable energy monitor (power meter). Only very small adjustments should be made.
Do not attempt to adjust the laser by adjusting either the front or rear mirrors at this point. Misalignment and severe internal damage can occur.

Front Mirror Adjustment / Replacement:



If it is necessary to remove or replace the front mirror the following procedure must be adhered to otherwise optical damage may occur.

To remove the front mirror:

1. On some older systems it may be necessary to move the HG crystal assembly in order to access the front mirror. In this case mark the position of the HG mount on the invar rail using a marker pen to ensure correct repositioning.
2. Loosen the HG mount tie bar screw and carefully slide the HG assembly along the invar towards the shutter assembly, bearing in mind the HG crystal assembly may still be hot.
3. The front mirror can now be removed by loosening the Front Mirror fixing screw as above. Note that the current design allows the front mirror to be removed through the front of its mount, eliminating the need to move the HG crystal assembly.
4. Clean or replace the front mirror as required, ensuring to tighten the fixing screw correctly.
5. Slide the HG crystal mount back into the marked position and tighten the tie bar screw.

Adjustment of front mirror:

1. Set the Mode to INT-Q for the laser to be optimised.
2. Set the Frequency to 1kHz
3. Set the Power to 45%
4. Arrange the power meter at the exit port
5. Open the Shutter.
6. Check the measured output corresponds with results stated in the test results at the back of this handbook.
7. Adjust the front mirror using the XY adjusters indicated above, adjusting for maximum output.
8. Refer to section 6.8 for adjustment of the HG mount, and repeat the adjustment for the cavity lens as per section 6.6.

9. Repeat adjustments of HG crystal mount, Front mirror and cavity lens in a cycle until the maximum output is reached. Do not increase the drive current until all 3 components are optimised.
10. Once the maximum output is achieved increase the drive current by 10% and repeat the 3 adjustments, continuing to do so in a cycle.
11. Continue to increase the drive current in 10% increments, repeating the 3 adjustments, until the maximum drive current is reached.
12. Ensure that section 6.2 Q-switch check is repeated at this stage otherwise optical damage may occur.

6.7 AO Q-switch Adjustment:

Frequency:	As Required
Skill Required:	Level 2 - Suitably trained, experienced and competent laser engineer
Safety:	Laser Radiation – Laser Safety Eyewear.
	Latex Gloves – Do not touch any optical surfaces.
Tools Required:	Piece of White card or Laser Phosphor Plate
	Fast rise time (ps) Photo Diode and Oscilloscope
	Calibrated Power Meter
Parts:	Non Required

WARNING: LASER RADIATION

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WARNING: RISK OF ELECTROCUTION

IT IS NOT NECESSARY TO OPEN ANY COVERS THAT REVEAL HIGH VOLATGES DURING THIS PROCEDURE. DOING SO MAY RESULT IN ELECTROCUTION.

CAUTION: RISK OF DAMAGE TO INTERNAL PARTS

1. Do not undertake this procedure unless you are competent to do so.
2. NEVER TURN THE LASER ENERGY ON AND OFF BY BLOCKING THE CAVITY.
3. ALWAYS USE THE LASER SHUTTERS. FAILURE TO DO THIS MAY RESULT IN OPTICAL DAMAGE
4. Do not touch any optical component directly as this may contaminate /damage the surface.
5. Ensure that all covers and protective covers are replaced correctly after completion.

Normal operation of the LDY-PIV series lasers requires that the AO Q-switch is able to hold off the internal energy of the laser cavity. Any leakage of radiation can potentially result in damage to the optical components. It is critical on initial installation to check that both Q-switches are holding off correctly, and checked periodically to ensure correct operation of the Laser system.

This procedure should only be undertaken once the simple Q-switch hold off test has been completed and green laser radiation was observed on the white card or laser phosphor.

This procedure has two (2) parts. The first part is how to determine which laser requires adjustment and the second part provides the method of how to adjust the Q-switch angle to achieve full hold off.

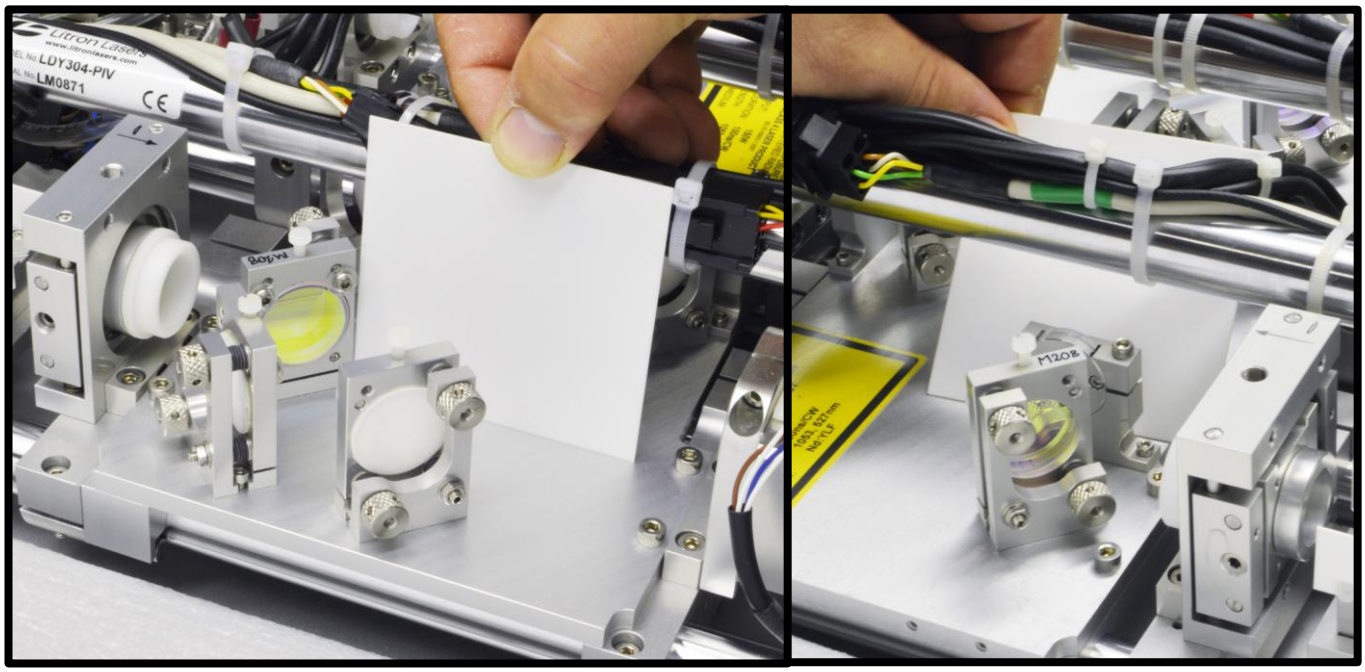
Part 1: Detecting incorrect tuning and determining which laser needs tuning.

Tools required:

Piece of hard white card.

Method:

1. **Remove the laser head outer cover.**
2. Start up the laser to the point where the pump is running and the **System** is **ON.**
3. Ensure the chiller and harmonic generators are at the correct set temperatures.
4. **DO NOT OPEN THE SHUTTERS**
5. Using the front panel control –switch the **MODE** for both lasers to **TRIG-Q**
6. **DO NOT CONNECT ANY SIGNAL TO THE TRIG-Q BNC CONNECTORS**
7. Set the **SHUTTER** to **OPEN**
8. **Place the white card at the positions shown in the images below.**
9. Observe the white card to see if there any green laser light present.
10. DO NOT ALLOW THE CARD TO INTERACT WITH THE LASER OPTICAL PATH



LASER 1 - Card Placement Position

LASER 2 - Card Placement Position

Figure 25: LDY-PIV Hold Off Check Positions

Part 2: How to adjust the Q-switch angle.
Tools required: See above.

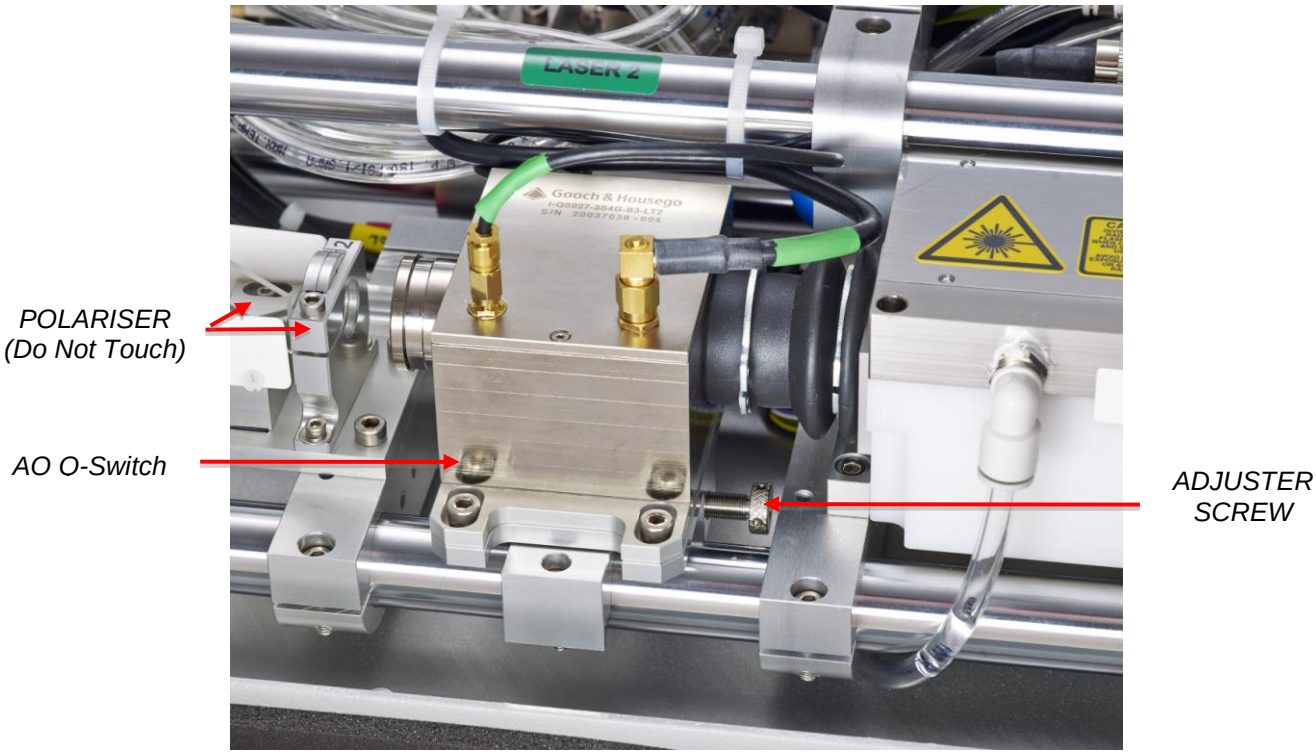


Figure 26: LDY-PIV Q-switch Alignment Adjuster

Method:

1. Arrange the white card used in part one in the correct location as per the above images.
2. With the Q-switch control set to TRIG Q (with no external trigger connected) there should be no laser output when viewed on a suitable white card placed in the output as described above.
3. If there is a slight green spot visible then the Q-switch is not holding off correctly and should be adjusted slightly until the green spot disappears.
4. The Q-switch is mounted on a rotating stage and the adjusting screw is arrowed above.
5. There is a Hold Off Window, an area of adjustment where there is no Laser output.
6. The Adjuster screw should be set in the middle of this window and then left. This is the safest area of operation for the Laser.

Under no circumstances should the Q-switch be adjusted when the Laser is running INT Q with shutter open.

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6.8 Harmonic Generator Mount Adjustment

Frequency:	As Required
Skill Required:	Level 2 - Suitably trained, experienced and competent laser engineer
Safety:	Laser Radiation – Laser Safety Eyewear.
	Latex Gloves
Tools Required:	Metric Allen Key Set
	Power Meter (Calibrated)
Parts:	Non Required

WARNING: LASER RADIATION

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WARNING: RISK OF ELECTROCUTION

IT IS NOT NECESSARY TO OPEN ANY COVERS THAT REVEAL HIGH VOLATGES DURING THIS PROCEDURE. DOING SO MAY RESULT IN ELECTROCUTION.

CAUTION: RISK OF DAMAGE TO INTERNAL PARTS

1. Do not undertake this procedure unless you are competent to do so.
2. NEVER TURN THE LASER ENERGY ON AND OFF BY BLOCKING THE CAVITY.
3. ALWAYS USE THE LASER SHUTTERS. FAILURE TO DO THIS MAY RESULT IN OPTICAL DAMAGE
4. Do not touch any optical component directly as this may contaminate /damage the surface.
5. Ensure that all covers and protective covers are replaced correctly after completion.

Procedure:

This procedure must not be undertaken unless the Q-switch hold off test has been completed and actioned before starting this procedure.

6. Set the Mode to INT-Q for the laser to be optimised.
7. Set the Frequency to 1kHz
8. Set the Power to 45%
9. Arrange the power meter at the exit port
10. Open the Shutter.
11. Check the measured output corresponds with results stated in the test results at the back of this handbook.
12. NOTE: WHEN ADJUSTING THE CRYSTAL THE ENERGY MUST NOT DROP MORE THAN 50% OF THE STARTING ENERGY.
13. The correct adjuster is marked with a yellow arrow.
14. Use an Allen Key inserted into one of the radial holes in the adjuster to turn it.
15. Make sure the Allen key doesn't get into the beam path as ablated material could get onto the optical surfaces.
16. Adjust the crystal for maximum output.

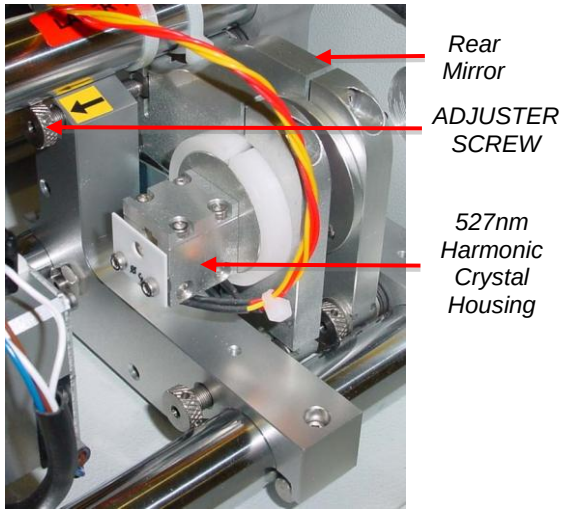

Figure 27: LDY-PIV Crystal Alignment Adjuster

17. Note that the energy may go through several false peaks before the maximum is achieved.
18. The beam profile will indicate that the correct peak energy has been achieved.
19. If the profile is an even fully filled oval shape and energy is at a peak the alignment is good.
20. If the beam profile is split or misshapen the alignment is not good.
21. Once the energy is maximised and the beam shape is good then increase the energy by 10%
22. Repeat the adjustment as above.
23. Repeat the 10% increase in power and alignment until maximum energy is achieved.

7. TROUBLESHOOTING

7.1 Interlock conditions

Figure 28: LDY-PIV Interlock Screen

1. **Laser Head:** This interlock is activated when the laser head cover is removed. It can be over-ridden using cable ties to allow routine adjustment of the beam alignment or cavity. Please refer to rail layout figure for positioning.

2. **Shutter:** The shutter has a micro switch that monitors its position. If the shutter fails to open within a set time after the shutter open request is made, or if the shutter is in an incorrect position the interlock will be activated. If the shutter interlock is activated, visually check the shutter. Switch the pump off and set 'SYSTEM' to 'ON'. Open and close the shutter and listen to check if you can hear the shutter opening and closing when the button is pressed.

3. **Driver Temp:** This interlock is not active on the LDY Laser system

4. **PSU Temp:** This interlock monitors the diode driver heat sink temperature. If this interlock is activated it may indicate that the cooling air supply to the heat sink has failed. Check to make sure that the cabinet cooling fans are running and that the filters are not blocked.

5. **External HG:** This interlock covers two conditions:

6. **External:** The external interlock is accessed by a plug and socket on the power supply back panel. It allows the system to be interlocked to an external input such as a door switch. **Never apply an external voltage to this connection, or connect to ground!**

7. **HG:** The harmonic generator (doubler) temperature controllers have an up to temperature interlock, this is incorporated into the External interlock circuit Please refer to harmonic generator temperature controls

8. **RF Driver 1 & 2:** Each of these interlocks monitors 3 conditions on its own laser. These conditions are as follows:

    a. Over temperature of the RF drivers. This may be caused by an interruption to the cooling water supply to the driver.

    b. Over temperature of the Q-switch (Modulator) on the laser head. This can be caused by an interruption of the cooling water flow.

    c. Incorrect VSWR condition. This can be caused by a disconnection or mismatch of the RF feed to the Q-Switch (Modulator). This condition can sometimes cause an interlock

condition when the system is first switched on, or when the system has been switched off and back on again. Pressing Laser On will clear the condition. Otherwise check for loose RF supply cables, on the power supply back panel or on the Q-switch (Modulator) connections at the laser head.

9. **Water temp:** The chiller has a defined temperature window of operation. The upper and lower limits are set at 16°C and 30°C. When these limits have been exceeded an interlock condition will occur. There will also be an audible alarm and a warning will flash up on the chiller control panel LCD. This is normal when the chiller is first switched on in cold ambient conditions as the water temp is likely to be below the lower limit. As the water heats up the alarm will change from a constant tone to intermittent then off. If the ambient temperature is very high it may be that the chiller will not be able to maintain the set control temp. The coolant temperature will then rise until the upper limit is reached, and again an audible alarm will be heard. Please refer to the section concerning chiller airflow and venting of hot air.

10. **Water level:** If the water level drops in the chiller for any reason an audible alarm will be heard and a warning will flash up on the chiller control panel LCD. A water level interlock condition will occur. Check for leaks and top up the chiller to the correct level.

11. **Water Flow**: As with the temperature the chiller is set to operate within a set water flow range. This will have a minimum value set to ~ 1L/min below the measured flow rate as detailed in the test results. The upper value is set as the standard default value of the chiller. If the flow rate falls below the set minimum value an audible tone will be heard and a warning will flash up on the chiller control panel LCD. Check for loose or twisted laser head water pipes, then if these are satisfactory, check and replace the filter element and cooling water. Refer to Particle filter replacement.

7.2 Fuse Allocations

FUSE	RATING	ALLOCATION
FS1	T2.5A	HG Temperature Controller Laser 1
FS2	T2.5A	HG Temperature Controller Laser 2
FS3	T1.0A	Emergency Stop
FS4	T15.0A	Chiller
FS5	T15.0A	Chiller