Brilliant EaZy

USER MANUAL

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TABLE OF CONTENTS

I. LASER SAFETY

II. INSTALLATION

III. LASER DESCRIPTION

IV. SYSTEM OPERATION

V. MAINTENANCE

VI. TROUBLESHOOTING

VII. APPENDIX

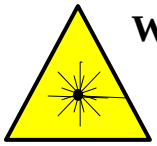
I. LASER SAFETY

I.1. GENERALITIES

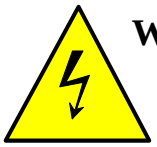
The Brilliant EaZy laser operator is responsible for applying the safety instructions indicated in this chapter.

Quantel shall not be held responsible for accidents to the user or to third parties caused by non compliant use of the equipment.

The warning symbols below will be used throughout this document to warn the user of important instructions which, if not followed, could lead to potential danger.



WARNING - LASER RADIATION, avoid exposure of eyes or skin to direct or diffused rays. Permanent ocular lesions may occur.



WARNING - HIGH VOLTAGE, electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or even death.

WARNING - DANGER other than those mentioned above

Information concerning laser safety addressed to the user in this document is in compliance with chapters 6.1 and 6.2 of the publication 825-1 by the International Electrotechnical Committee concerning laser product radiation safety, published by the Central Office of the International Electrotechnical Committee, 3 rue Varembé, Geneva, Switzerland. 1993 Issue.

Other laser safety references may also be consulted in the following documents :

- "**European Standard and French standard"**: NF EN 60825-1 June 2000, classification index: C43-805.

- **"Safe Use of Lasers"** (Z136.1)
  American National Standards Institute (ANSI)
  11th West 42nd Street
  New York, NY 10036 USA
  Phone: (212) 642-4900

- **"A Guide for Control of Laser Hazards"**
  American Conference of Governmental and Industrial Hygienists (ACGIH)
  6500 Glenway Avenue, Bldg. D-7
  Cincinnati, OH 45211 USA
  Phone: (513) 661-7881

- **"Occupational Safety and Health Administration"**
  U.S. Department of Labor
  200 Constitution Avenue N.W.
  Washington, DC 20210 USA
  Phone: (202) 523-8148

- **"Safety of Laser Products"** (EN60825-1:1994)
  Global Engineering Documents
  15 Iverness Way East
  Englewood, CO 80112-5704 USA
  Phone: (303) 792-2181

- **"American National Standards for the Safe Use of Lasers"**:
  ANSI Z136.1-1993 available from Laser Institute of America,
  12424 Research Parkway, Suite 125,
  Orlando, FL, 32826.

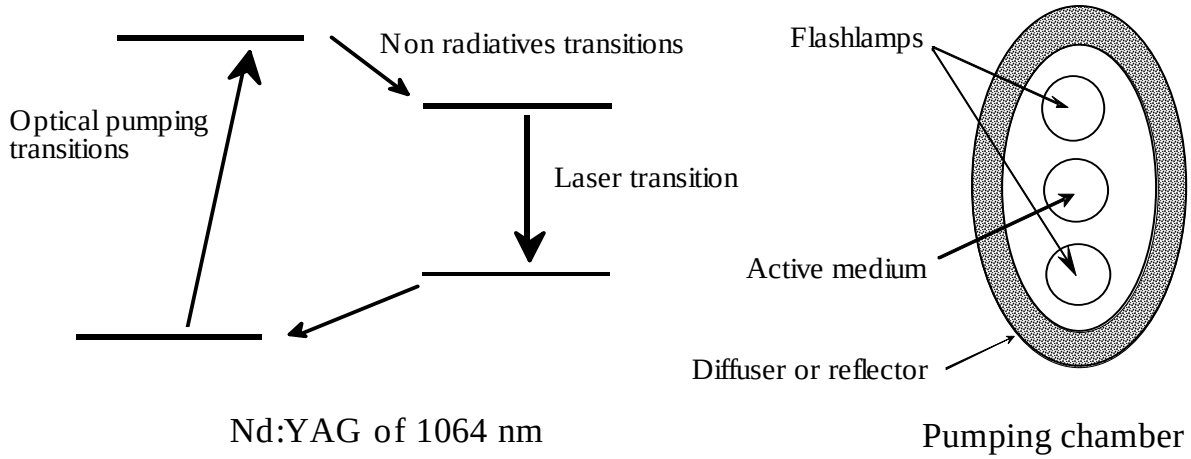
- **"Compliance Guide for Laser Products."**

HHS Publication FDA 86-8260.
U.S. Department of Health and Human Services. FDA.
Center for Devices and Radiological Health.
Rockville, Maryland 20857.

I.2. LASER OPERATION PRINCIPLE

A laser is a coherent, collimated monochromatic light source. An excited medium may be brought back to its fundamental state by emitting photons (light waves), in a spontaneous and non coherent manner, as in natural light sources. In the laser emission process (**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation), an incident photon on active excited atoms creates a similar photon in terms of wavelength and phase when depleting the atom to its fundamental energy state. The medium in which the laser emission is produced is referred to as the active medium or amplifying medium.

The active medium may be excited in several manners, optical pumping (by absorbing light), collision with electrons or atoms, chemical reaction, etc.



Draw I-1: Diagram of the Nd:YAG atomic transition principles and transversal view of a Brilliant EaZy pumping chamber.

On the left, the Draw I-1 shows a diagram of the atomic transition principle of the active medium used in Nd:YAG solid state lasers (**N**éo**d**ymium : **Y**ttrium - **A**luminium - **G**arnet). On the right of the Draw I.1, is shown a transversal view of an optical pumping chamber in which the light emitted by the lamp is transferred to the active medium by a direct path or after having been diffused or reflected.

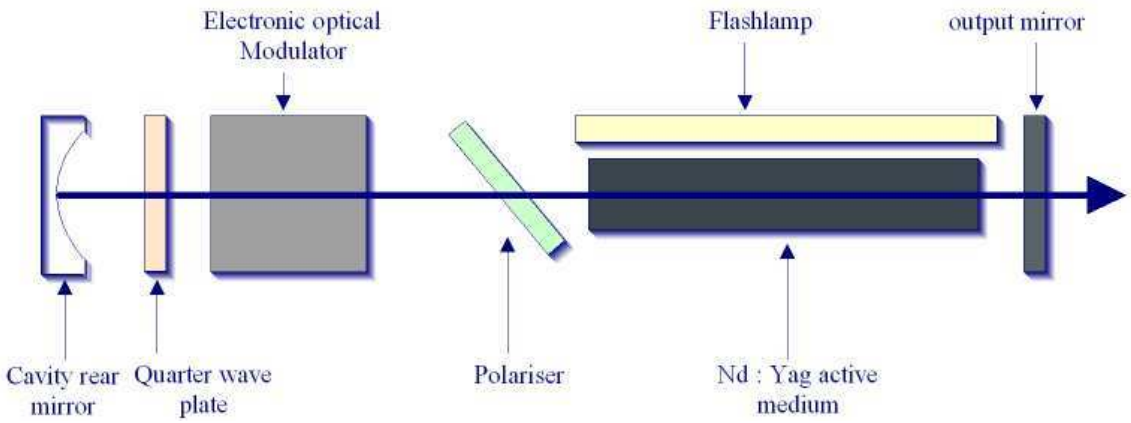
Amplification is increased to a considerable degree if the waves emitted are forced to pass through the same active medium several times. This active medium is placed in an optical cavity composed of two or several mirrors, in order that the light wave will be amplified after having passed through the amplifying medium several times.

The laser emission is obtained at the output of the cavity (resonator), by means of one of the mirrors which may be partially reflecting or is extracted from the cavity by other means.

The laser emission may be continuous or by pulses as energy packets, depending on the excitation mode of the active medium and the mode to extract laser light from the cavity. The pulse emission mode may be divided into two, the free running mode and the Q-Switched mode.
With non continuous pumping, the laser emission in the free running mode is obtained as long as amplification is above the losses in the resonator until the end of the pumping. Laser emission in the Q-Switched mode is obtained by preventing light (through big losses) from travelling back and forth in the cavity and by suddenly enabling emission (fast losses reduction or «Q-switching») after having stocked a sufficient amount of energy in the amplifying medium.

For the same amount of laser energy emitted in each mode, the Q-Switched pulse duration is approximately 30 000 times shorter than in the free running mode; i.e. the peak laser pulse power is approximately 30 000 times greater in the Q-Switched mode than in the free running mode.

The Draw I-2 depicts a simplified diagram of a Brilliant Eazy Nd:YAG type Q-Switched laser, similar to that used in the Brilliant. The cavity (resonator) is comprised of the cavity rear mirror with maximum reflectivity and the partially reflecting output mirror. The active medium is a Nd:YAG rod optically pulse-pumped by a flashlamp for the Brilliant eazy. The three other components (polarizer, quarter wave plate and the electro-optical modulator) are used to block and to Q-Switch the laser emission.



Draw I-2: Simplified diagram of a Brilliant EaZy Nd:YAG Q-Switched laser.

I.3. LASER EMISSION CHARACTERISTICS

I.3.a. WAVELENGTH

Depending on the active element the laser emission may be obtained in ultraviolet, visible, or infrared. The Nd:YAG Brilliant family lasers emits at 1064, 532, 355, 266 and 213 nm.

I.3.b. PULSE DURATION

Depending on the operating mode and other laser parameters, the pulse duration may range from continuous emission to ultra short

pulses of approximately 10^{-13} seconds. The Q-Switch operating mode of the Brilliant family lasers leads to laser pulses of approximately 4-6 ns (1 ns=10^{-9} seconds).

I.3.c. ENERGY PER PULSE

Depending on the type of laser, the laser pulse energy may range from 10^{-13}J to 10^{6}J. Brilliant EaZy lasers are able to provide energy per pulse as high as 330mJ respectively at 1064nm. For other wavelength please refer to the data delivered with the laser.

I.3.d. AVERAGE LASER POWER

The average power value of a pulsed laser is obtained by multiplying the energy per pulse and the repetition rate (frequency). At 10 Hz, Brilliant EaZy average powers is 3.3W @ 1064 nm.

I.3.e. BEAM DIVERGENCE

The beam divergence for the standard lasers is less than 0.5mrad depends on the frequency repetition rate of the laser. This divergence is measured at $1/e^2$ of the peak, 85% of total energy.

I.4. LASER CLASSIFICATION

Due to the extent of the laser emission characteristics (wavelength, energy, etc.), the risks caused by use of the laser are highly variable. It is impossible to consider lasers as a single group to which shared safety limits may be applied. Laser devices are divided into four general classes, the Accessible Emission Limits (**AEL**) is specified for each class.

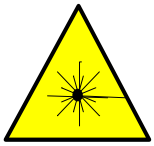
- **Class 1:** Lasers which present no danger in all reasonably foreseeable use conditions.

- **Class 2:** Lasers which emit a visible ray within the wavelength range of 400 nm to 700 nm. Eye protection is normally ensured by the defense reflexes, including the palpebral reflex.

- **Class 3A**: Lasers which present no danger for naked eye vision. For lasers which emit a visible ray within the wavelength range of 400 nm to 700 nm, eye protection is normally ensured by the defense reflexes, including the palpebral reflex. For other wavelengths, the risks to the naked eye are no greater than those for class 1. Looking directly into the class 3A laser beam using optical instruments (for example: binoculars, telescopes, microscopes) may be dangerous.

- **Class 3B**: Looking directly into the beam of these lasers is always dangerous. Normally, looking at diffuse reflections presents no danger.

- **Class 4**: Lasers which are also capable of producing dangerous diffuse reflections. They may cause skin damage and may also constitute a fire hazard. There use requires extreme precautions.



THE BRILLIANT EAZY LASER BELONG TO CLASS 4

I.5. RISK EVALUATION AND PROTECTION MEASURES

Three aspects of laser use must be taken into consideration when evaluating the possible risks and applying protection measures:

- Possibility that part of the human body receive the laser ray directly, by reflecting on a reflecting surface or by scattering on an object.
- The environment in which the laser system is used.
- The level of training of the personnel which operates the laser or which may be exposed to its rays.

The safety of the installations which use the laser is of utmost importance, a competent person must be designated as responsible for laser safety. This person is to be in charge of checking that all the measures of safety are applied by the person or people who use the laser system; this person is also to provide insight into special use situations.

I.5.a. RISK EVALUATION FOR CLASS 4 LASERS

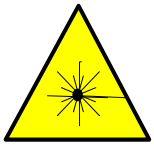
The potential risk of class 4 laser systems may extend to a considerable distance. The distance from the laser, for which the lighting or energy exposure falls below the appropriate MPE (Maximum Permissible Exposure limit) is referred to as the NORD **(**Nominal Ocular Risk Distance). The NORD depends on the laser emission characteristics, the appropriate MPE, the type of optical system used and the effect of the atmosphere on the propagation of the beam. The area within which lighting or energy exposure of the beam exceeds the appropriate MPE is referred to as the NORA **(**Nominal Ocular Risk Area). This area is determined by the site and azimuth

pointing limits of the laser system and extends either to the NORD limit, or to the target, or to a beam limiter. The exact NORA area also depends on the type of equipment located along the beam trajectory.

The NORD is measured by organizations competent to evaluate laser risks.

I.5.b. INSTALLATION OF CLASS 4 LASER SYSTEMS

Class 4 laser systems may produce lesions both by the direct beam or its specular reflections and by diffuse reflections. They also represent a potential fire hazard. These systems must only be implemented by personnel with sufficient experience with their operation; this personnel must be approved by the laser safety officer. The safety rules explained below must be read and followed by everyone who uses the laser.



ALWAYS WEAR PROTECTIVE GLASSES

1. Never look at the direct beam from the laser or from a hand piece or one of its reflections. No visual alignment should be made when the electric power supply of the laser is on. Irreversible ocular lesions may result.

2. Avoid exposing any part of the body to the beam. Limit access to the work area to the required personnel only. Evacuate all objects with a reflecting or shiny surface from the work area, as well as all inflammable materials.

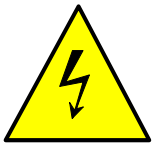
3. The laser beam emission area must be lit correctly in order that the eye pupils of the people present open as little as possible, which limits the amount of light which penetrates into the eye and reduces the risks of lesions.

4. Only use the laser in supervised areas which are clearly marked and have supervised access. It is recommended that access ways to **work areas** be equipped with contactors connected with the external safety loop of the laser. If opened, the laser emission is automatically stopped. The sign supports must be appropriate and clearly visible.

5. During normal operation, the **laser area** (work area) must be marked off by means (screens, walls, etc.) which ensure that laser rays outside the area are less than the AEL (class 1 type laser).
   These means must not be covered by materials which may reflect the laser wavelength. These screens must not be inflammable, nor must they allow laser rays greater than the AEL limit to pass when submitted to the direct laser beam as used in the area, even for several seconds. Around the laser area, a **warning area** limited by barriers is necessary to warn all people of the potential risk which lies within the laser area.

6. Only qualified people may operate the lasers. When not in use, the lasers must be completely inoperable and it must be made impossible for unauthorized people to operate them, for example, by removing the laser key.

7. Using laser radiation to aim at individuals, vehicles, aircraft or any other flying object is formally prohibited.



8. To prevent the electric risks, the power supplies must be switched off prior to any maintenance operation. Electric shocks or burns resulting from the power supply of the network or from condenser discharges may cause serious wounds and traumas. They may be fatal.

I.6. MEDICAL CONSIDERATIONS

I.6.a. RISK TO THE EYE

The characteristics according to which eyes absorb rays of various wavelengths vary depending on the medium of the eye through which the rays pass. Thus, distant ultraviolet and infrared ray laser emitters are dangerous for the cornea, while rays from visible and near infrared wavelength emitter systems are transmitted to the retina. Visible and near infrared lasers present particular risks for eyes. This is due to the fact that highly pigmented tissues may be submitted to strong energy exposure. The increase in the energy lighting when passing from the cornea to the retina is approximately equal to the ratio of the distance between the pupil's surface area and that of the retina image. This increase results from the light which enters through the pupil and focuses on one point on the retina. The opening of the pupil is variable, but its diameter may reach 7mm when a young eye is dilated to its maximum. The retina image corresponding to such a pupil may have a diameter between 10µm and 20µm. The increase in lighting between the cornea and the retina lies between 2×10^5 and 5×10^5. If the increase is said to be 5×10^5, a beam with an energy density of $50 W/m^2$ on the cornea becomes $2.5 \times 10^7 W/m^2$ on the retina.

If an intense laser light beam converges on the retina, only a small part of the light (5%) is absorbed by the visual pigments of the cones and rods. Most of the light is absorbed by the pigment referred to as melanin. The energy absorbed may cause a local rise in temperature. This burn or lesion may cause loss of eyesight.

Such loss of eyesight may or may not be permanent, depending on the amount of exposure. In general, people exposed only subjectively notice a decrease in eyesight if the central part of the macula is affected. The fovea, the hollow at the centre of the macula, is the most

important part of the retina since it is responsible for the clearest vision. This part of the retina is used to "look directly at something". If this region is injured, the decrease in eyesight may begin as a blurred white spot which blocks the central area of vision, but within two or several weeks, the white spot may become black. Peripheral lesions are only noticed if the retina is greatly damaged.

Everyone present in the laser operating area must wear protective glasses when the laser system is in operation. Very low energy (microjoules) emitted by a Nd:YAG pulsed laser may cause irreversible ocular lesions. The optical density (O.D.) of the glasses must be in compliance with standard EN 207, 1993, at least. In the following recommendations we have consider protective glasses located in the range of 0-2m from the output of the laser and in direct exposure to the laser beam.

Wavelength (nm)	O.D.	L.
1064	>6	>7
532	>7	>7
355	>3	>6
266	>3	>2
213	>2	>1

ALWAYS WEAR PROTECTIVE GLASSES and never look at the direct beam from the laser or from any of its reflections.

The user should calculate in compliance with standard EN 207, 1993, or other standards applied in his country, what O.D. will match his use of the laser.

I.6.b. RISK FOR THE SKIN

In general, skin can withstand far greater exposure to laser beam energy than eyes. The biological effect of skin radiation by lasers

operating in the visible spectral regions (400 to 700 nm) and infrared regions (700 to 1060 nm) may vary from a benign erythema to large blisters. Superficial grey colour carbonization after exposure to very short, high peak power laser pulses is common in tissue with high superficial absorption. This phenomenon is not necessarily followed by an erythema.

Pigmentation, ulceration, appearance of scars on skin and lesions in subjacent organs may result from extremely strong lighting. It has been noticed that the latent or cumulated effects of laser rays are not very common. However, some limited research suggests that, under particular conditions, repeated local exposure may render small parts of human tissue more sensitive, which leads to a modification in the exposure level concerning minimum reactions and aggravation in reactions in the tissues for such low level exposure.

I.6.c. MEDICAL FOLLOW-UP

Since there is no European or national regulation, the following recommendations are to be taken into consideration:

- The quality of the medical follow-up of people who work on laser systems is a fundamental problem which remains the medical profession has not resolved to date. If ophthalmologic examinations are undertaken, they must be done by a qualified specialist. **We recommend an ophthalmologic examination each year.**

- A medical examination should be done by a qualified specialist **immediately after ocular exposure which appears to be harmful or is presumed to be harmful.** The examination should be accompanied by a biophysical inquiry into the circumstance under which the accident occurred.

- Ophthalmologic examinations prior to employment, for temporary employment or post employment for personnel who use lasers only have value for medical-legal considerations.

I.7. SPECIAL HEALTH AND SAFETY INSTRUCTIONS

Since there is no European or national regulation, the following recommendations are to be taken into consideration:

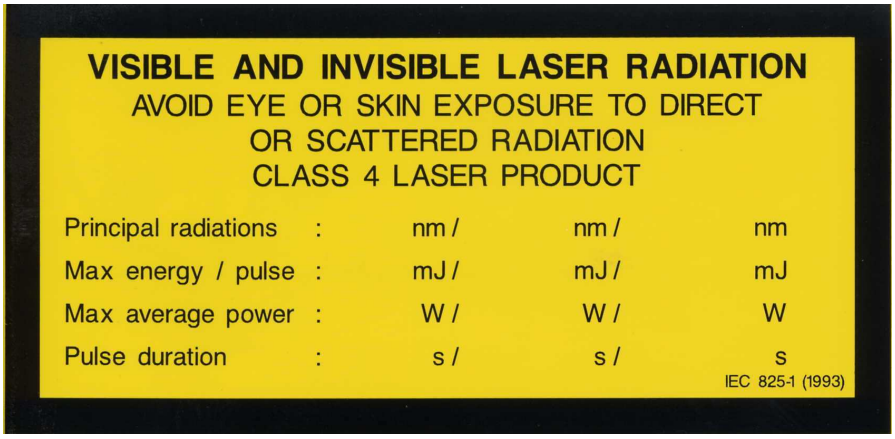
- The quality of the medical follow-up of people who work on laser systems is a fundamental problem which remains the medical profession has not resolved to date. If ophthalmologic examinations are undertaken, they must be done by a qualified specialist. **We recommend an ophthalmologic examination each year.**

- A medical examination should be done by a qualified specialist **immediately after ocular exposure which appears to be harmful or is presumed to be harmful.** The examination should be accompanied by a biophysical inquiry into the circumstance under which the accident occurred.

- Ophthalmologic examinations prior to employment, for temporary employment or post employment for personnel who use lasers only have value for medical-legal considerations.

I.8. SAFETY LABELS AND THEIR LOCATION

I.8.a. LABELS

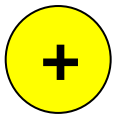


Label n° 1

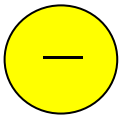
Label n° 2

Label n° 3

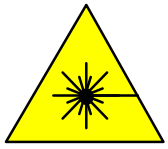
Label n° 4



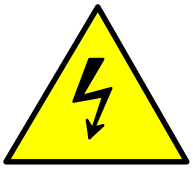
Label n° 5



Label n° 6

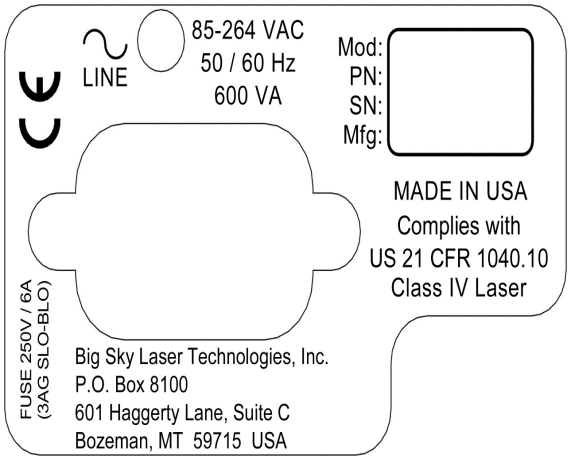


Label n° 7



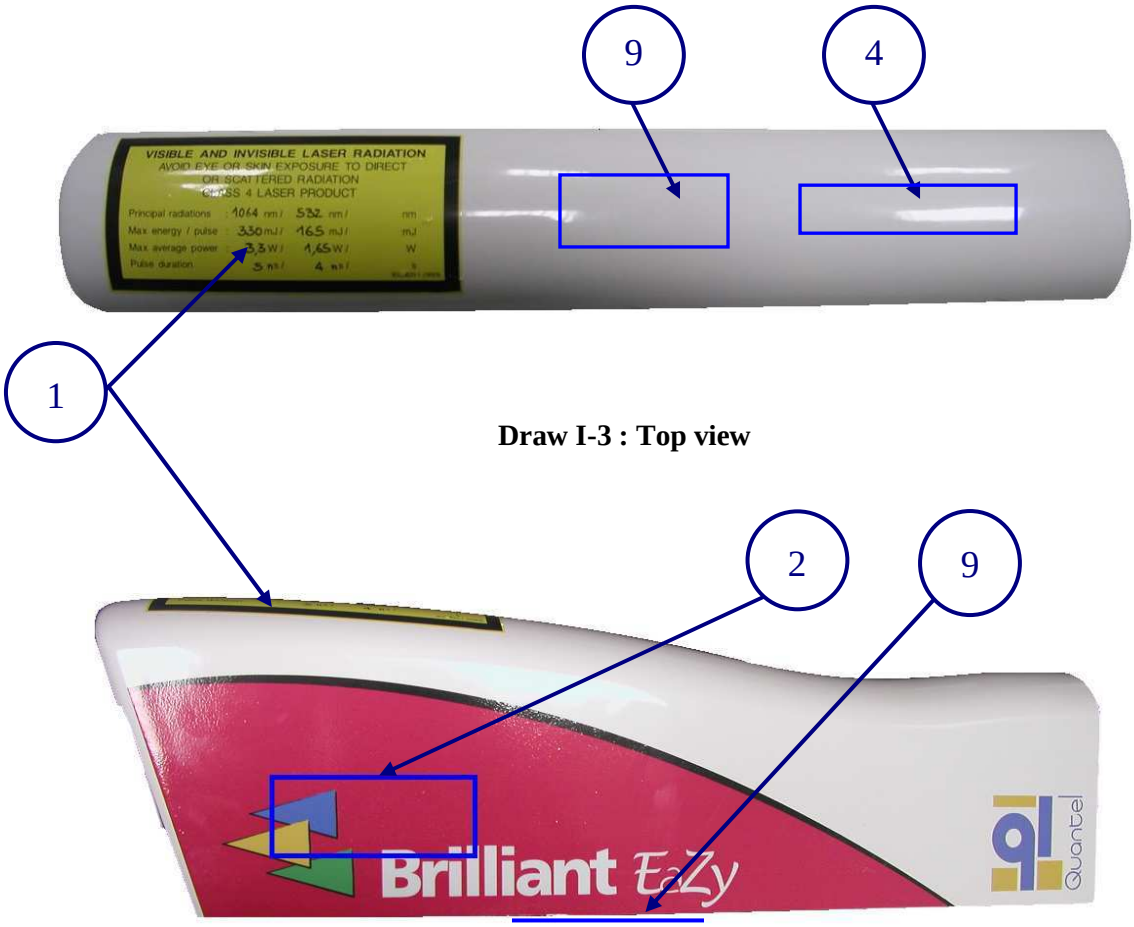
Label n° 8

Label n° 9



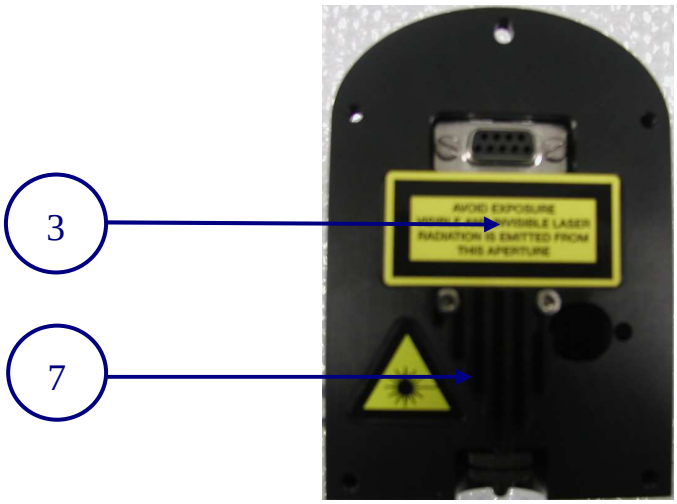
Label n° 10

I.8.b. LOCATIONS

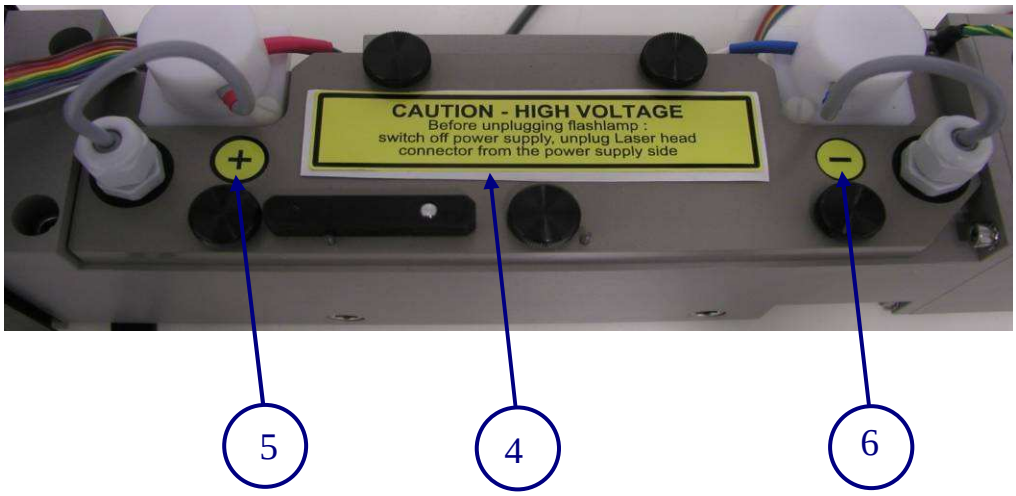


Draw I-3 : Top view

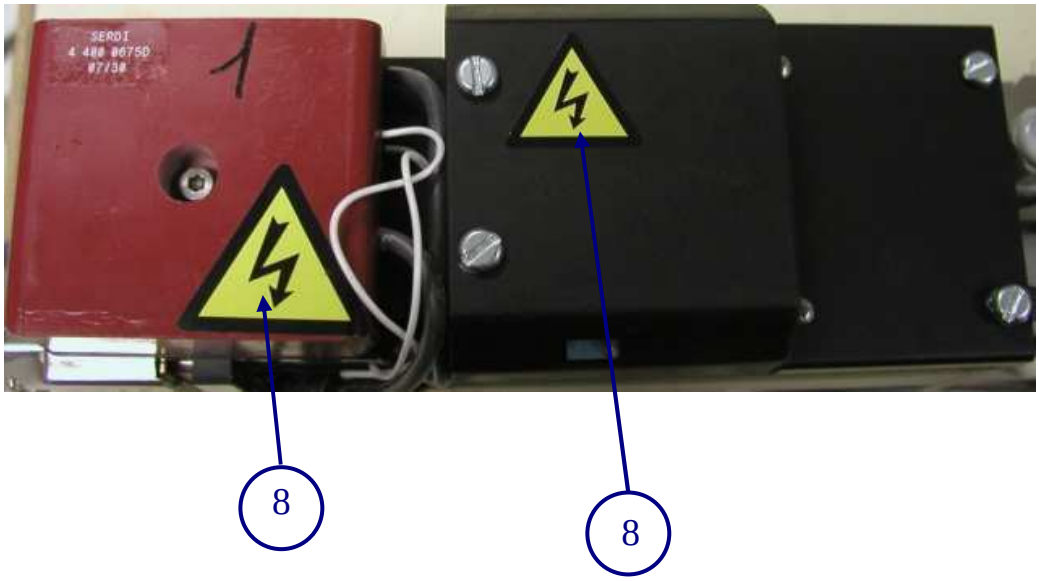
Draw I-4 : Side view



Picture 1: Beam output panel view



Picture 2: Pumping cavity view



Picture 3: Transformer trigger and Q-Switch view

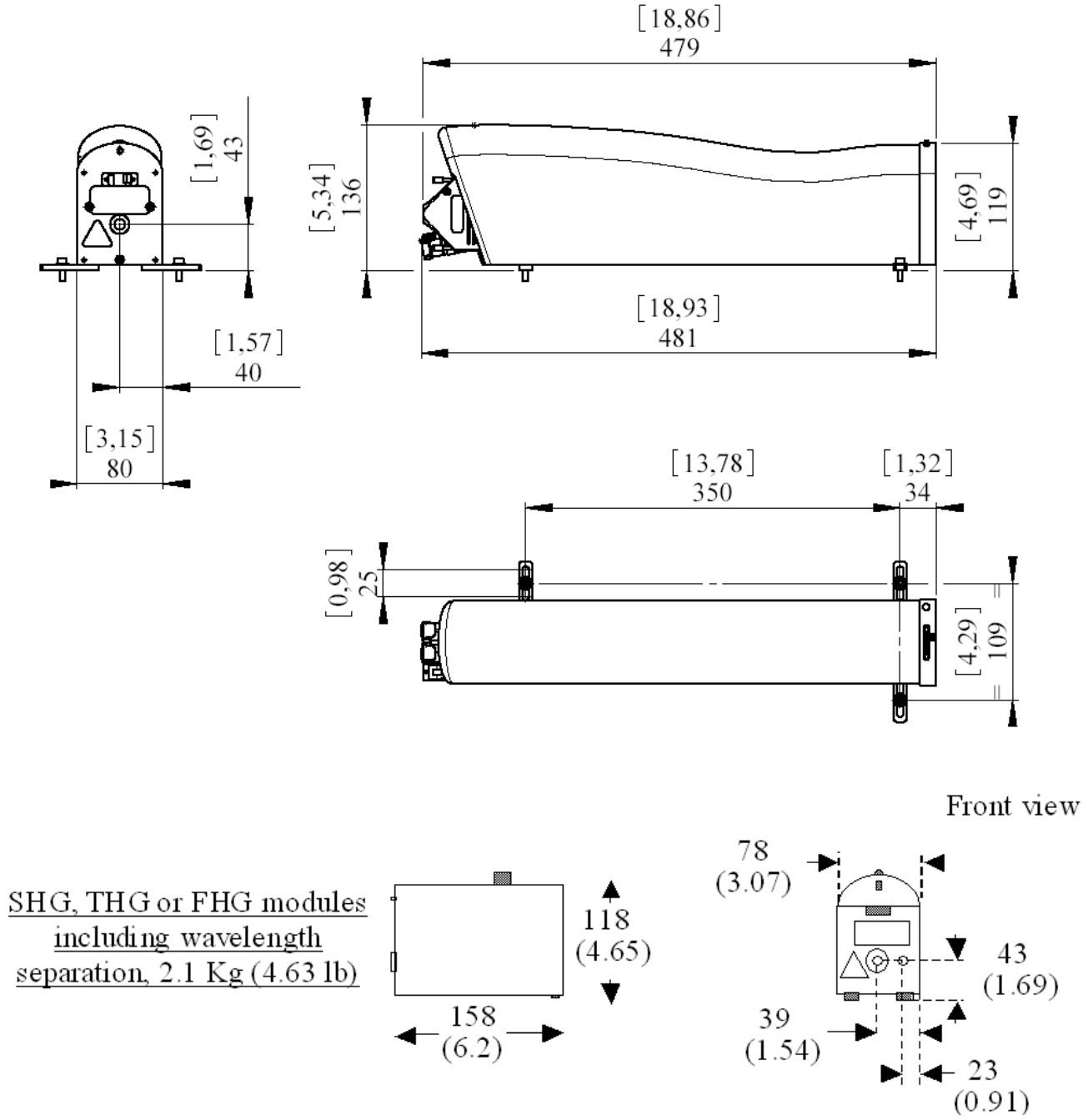
Figure I-1: Electronic cabinet rear panel view

II. INSTALLATION

II.1. PHYSICAL DESCRIPTION OF THE LASER

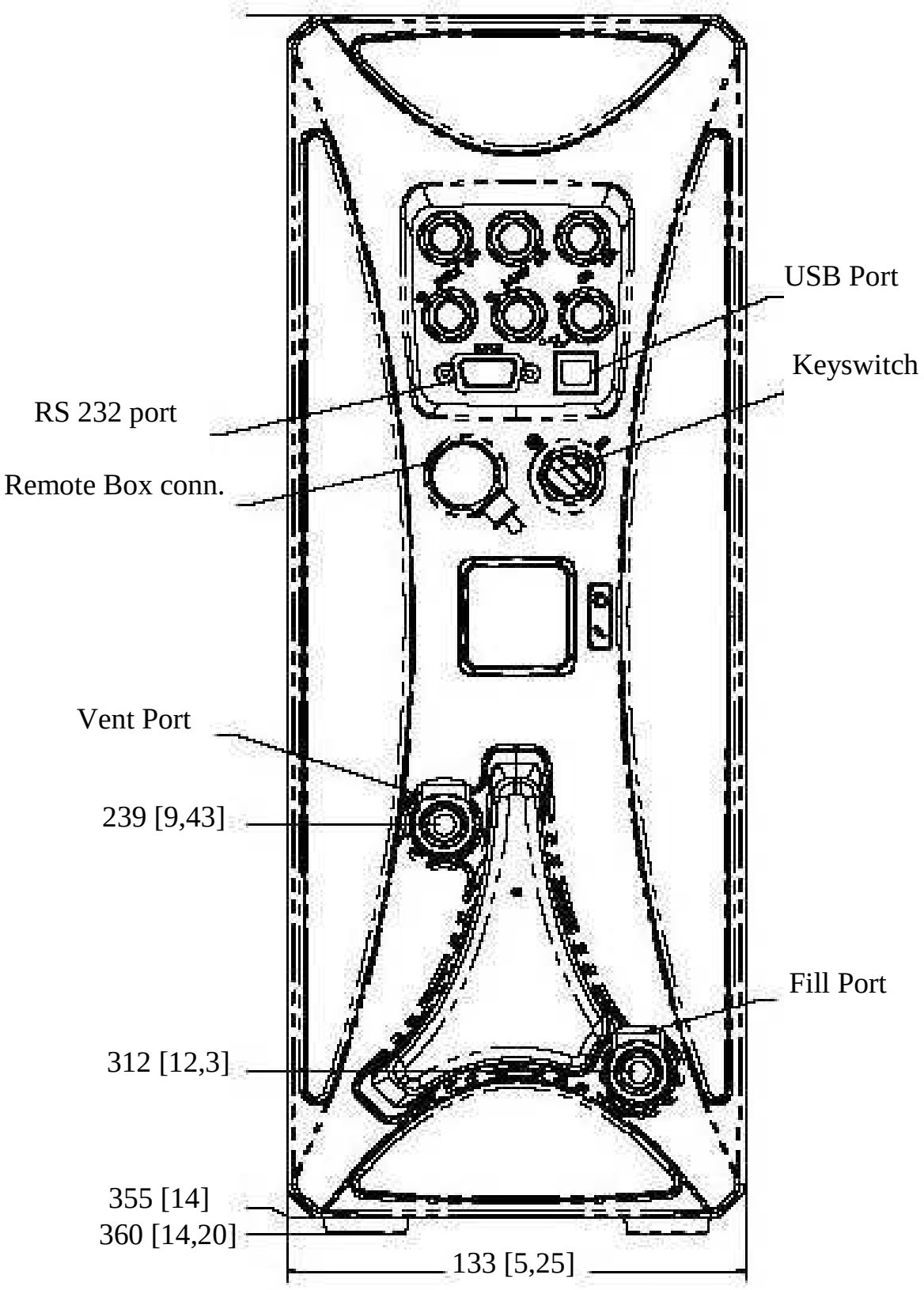
QUANTEL's Brilliant Eazy Q-Switched Nd:YAG lasers are both very compact systems. The footprints for the optical laser heads are 8 x 47 cm2 for Brilliant The foot prints for each SHG, THG or FHG module including wavelength separation is 7.8 x 15.8 cm2.

The footprint of the power supply and air cooling group cabinet is 28.6 x 59.2 cm2. Draws II-1, II-2 & II-3 show all details of the physical dimensions of laser head, options and cabinets. The umbilical connection between the laser head and the power supply and cooling group cabinet is 3m long.



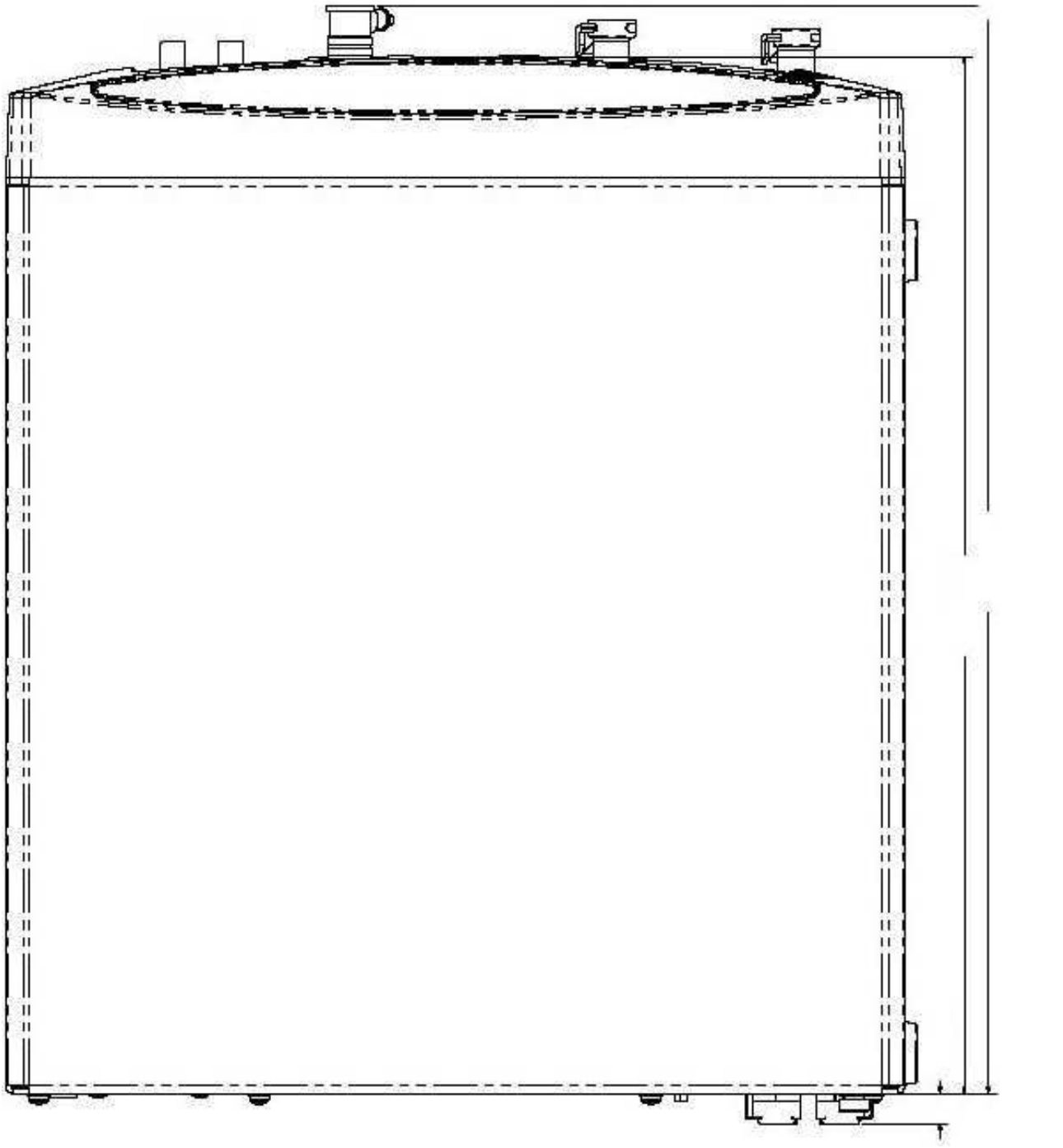
Draw II-1 : Laser heads, all dimensions are in mm (inch)

Weight: 14 kg [31 lb]; dimensions in mm [Inch]



Draw II-2: Brilliant EaZy ICE, front panel, all the dimensions are in mm [in]

Dimensions in mm [Inch]



Draw II-3: Brilliant EaZy ICE, side panel, all the dimensions are in mm [in]

II.2. INSPECTION AFTER SHIPMENT

Check the crate for damage before uncrating the laser. Take note of all visible external damage. Unpack the reusable crate, uncrate and unwrap the laser, take off the optical head first, then lift up the cabinet and take it out of the crate. Check it for external damage (scratches, dents, etc.).

Please notify within 3 days both the carrier and QUANTEL S.A. or its representative of any damage.

II.3. INSTALLATION

II.3.a. REQUIREMENTS

II.3.a.i. ENVIRONMENT

The laser head is a precision-machined monolithic alloy block, which ensures alignment and parallelism of the resonator mirrors. It is temperature-stabilized by a water loop, which goes through a water/air heat exchanger Brilliant EaZy located in the cabinet. For proper operation of the laser the ambient temperature ranges are:

Brilliant EaZy: 18°C to 28°C

The laser should be positioned on a solid worktable.

When choosing a place for your laser, keep in mind that access should be available from all sides, and the remote control box access should be within reach of the user.

Choose a location for the Power supply and Integrated Cooler and Electronics (ICE) so that each side, the front and rear panels of the

cabinet must not be obstructed and have to be at least 50 cm away from a wall or other obstacle to allow efficient cooling of the laser head and power supply. The airflow is from front side to rear side for Brilliant EaZy.

II.3.a.ii. UTILITIES

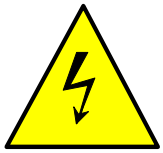
A three-point power supply is required: 1 phase + neutral + ground. The voltage available can be between phase and neutral 85V to 260V (50/60 Hz). This information is indicated on the label n°10 (see chapter I-8) at the rear panel of the ICE. The wire colours are: blue for neutral, black or brown for the line, and yellow/green for the ground.

II.3.b. INSTALLATION

II.3.b.i. GENERALITIES

No attempt should be made by the user to start up the laser before applying the installation instructions. Damage occurring due to the non application of these instructions will not be covered by our warranty.

QUANTEL's Brilliant EaZy Q-Switched Nd:YAG laser does not require installation by a QUANTEL's technician or a QUANTEL's representative. Brilliant EaZy whose design is based on years of field-proven technology, are so reliable and user-friendly that installation can be managed by the user. The installation can be performed in two steps.



Before performing these steps, be sure that the Power supply cabinet (ICE) is not connected to the main.

II.3.b.ii. SECURING TO A OPTICAL TABLE

The only tool that you need to secure the laser to an optical table is a metric Allen key n°5 for M 6 screw. However, a set of metric Allen keys are delivered with the laser.

Put the laser on the table and please proceed as follow (see Draw II-4):

1. Unscrew the screw on the back side of the protective housing shown in (1).

2. Slide the protective housing toward the rear side of the laser by about 20 mm, and pull it off.

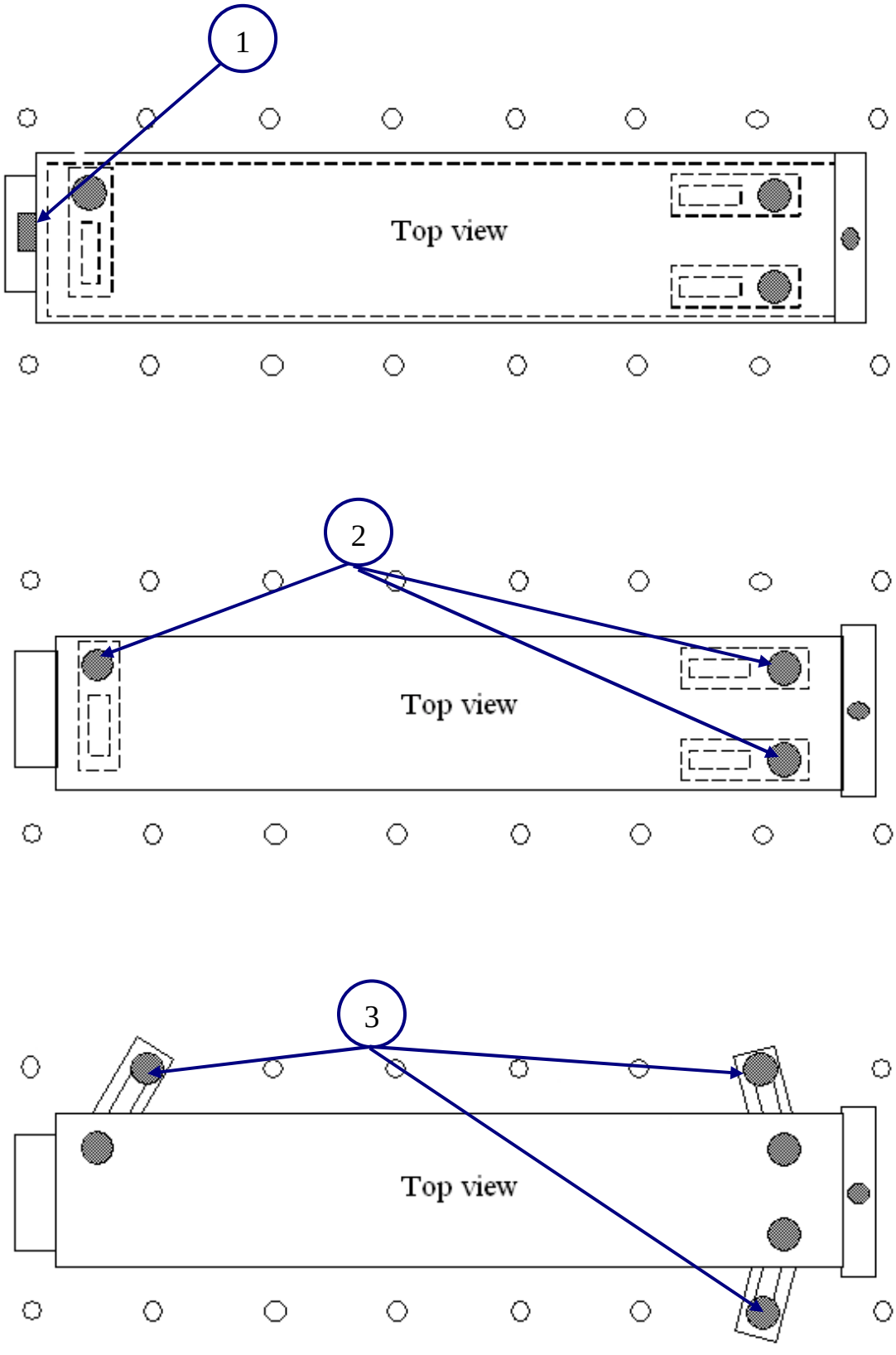
3. Slightly loosen the three legs and rotate them to fit holes on your table.

4. Insert and tighten the three screws shown in (3) (delivered with the laser) to secure the legs to the table. If these screws don't fit the holes of your table you can replace them. However, if these legs do not match your requirement, replace them by your own with the same design, keeping the same mounting arrangement on the optical head and your table.

5. Tighten the screws shown in (2).

6. Put back the protective housing by reversing step [2] and [1]. The protective housing should go inside the groove at the front end of the laser.

7. If the laser is delivered with one or two harmonic generator, slightly screw the supporting leg at bottom of front end until it is just in contact with the table, and lock it with the nut.



Draw II-4: Securing the laser to an optical table

II.3.b.iii. LASER HEAD CONNECTION

The umbilical is about 3 m long. It connects the optical laser head to the power supply cabinet, and includes:

a. High voltage cables to the flashlamp.

b. Coolant hoses.

c. Laser safety, power supply for HGM, synchronization lines.

d. Earth conductor.

Optical head connection requires Allen key tools, which are delivered with the laser. To connect the optical head of the Brilliant EaZy, proceed as follows:

1. Plug the electrical connector (2 on Figure II-1) into the ICE (Integrated Cooler and Electronics). Take off the Brilliant Eazy Head cover, plug the electrical connector into the head and put the cover on (the connectors are keyed so that they may not be connected incorrectly) and **tighten** the connector cover screws (3 on figure II-2).

2. Plug the two umbilical coolant tubes on the ICE (1 on Figure II-1). Note that the coolant fittings are different at each end of the umbilical coolant tubes. The fittings without a shut-off in the end should plug into the Laser Head. Be sure there are no endcaps on the laser head coolant tubes.

3. Tighten the coolant fitting connector.

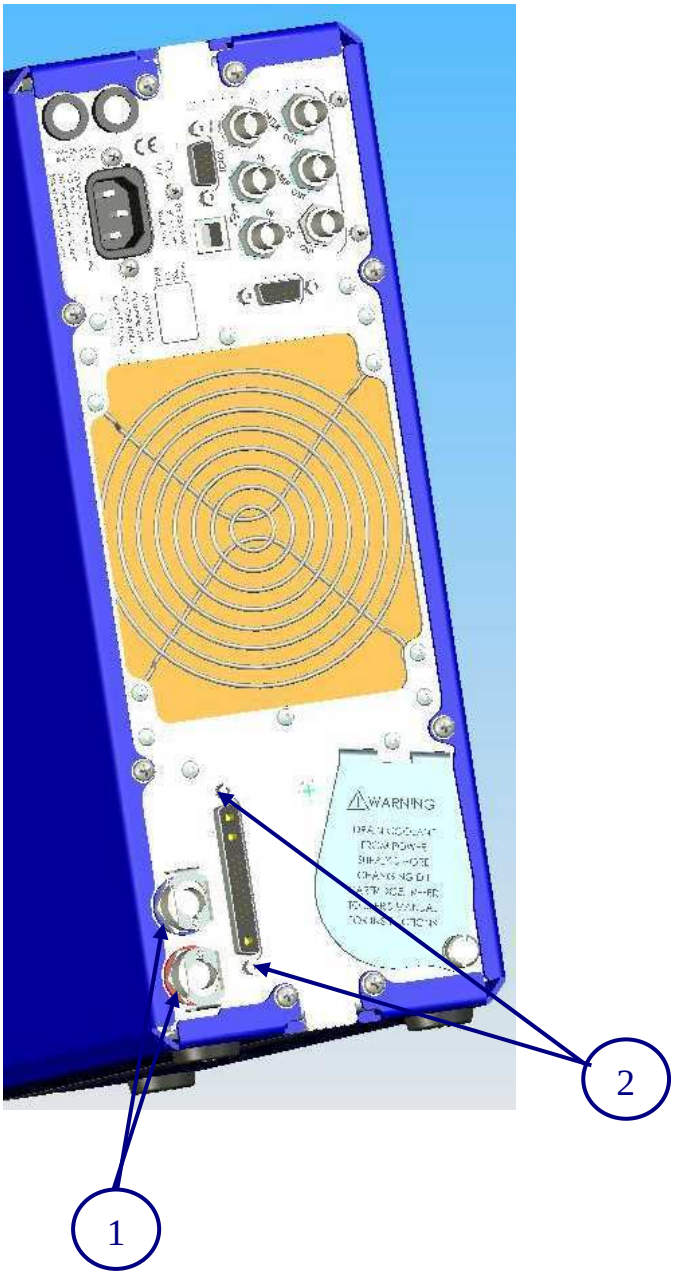


Figure II-1: ICE water and electronic connection on back panel

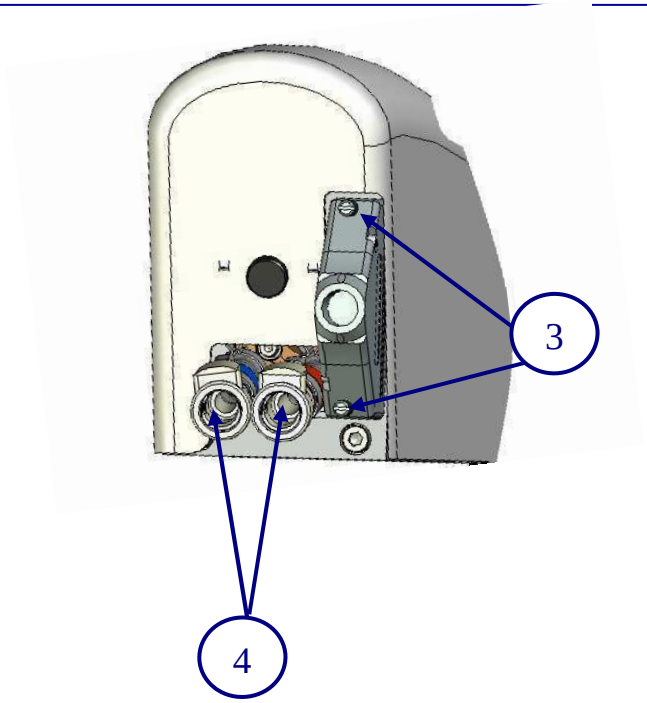


Figure II-2: laser head water and electronic connection

II.3.b.iv. LIQUID/AIR COOLING GROUP FILLING/DRAINING

Before shipping the laser from Quantel, the coolant has been drained from the coolant tank. To prepare the cooling group for use, the operator has to fill this tank with about 1.5 L of demineralised water or other Quantel-approved coolant. Please proceed as follows:

1. Fill the bottle with coolant. Attach coolant fill/drain connectors. The fill bottle is connected to fill/drain fitting, and the fitting with a hose is attached to the upper vent fitting. Loosen the cap on the fill bottle, and add coolant until coolant drains from the vent fitting.

2. Turn the key switch ON. The pump will turn on automatically after power up, and coolant will begin filling the umbilical coolant lines. When the reservoir level falls below the depression in the middle front of the reservoir, the pump will shut off and the illuminating lights in the reservoir 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 backlights will remain on continuously.

3. 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 ICE as far as it can go – gravity will cause the coolant to be drained from the system. This is adequate to remove most of the coolant from the system, but is not sufficient to prepare the ICE for shipment when freezing conditions are present if water is used as the coolant.

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, as there are places within the ICE where water can become trapped, and irreversible damage may occur to the internal components when the water freezes. Disconnect the umbilical coolant lines from the ICE and drain the water from the Laser Head (follow the steps described in III.3.e). Then disconnect the umbilical coolant lines from the Laser Head and reconnect the red fitting to the ICE. 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. Then disconnect the red fitting from the ICE, 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 ICE forward to cause the water to run to the front. Following this detailed procedure will drain all the water from the system, and ensure the best possibility of preventing freezing damage during shipping.

Note: The ICE will briefly make a "buzzing" sound when the key switch is turned on. This is normal. The A/C front-end electronics are current-limiting the inrush current during power up, resulting in the "buzzing".

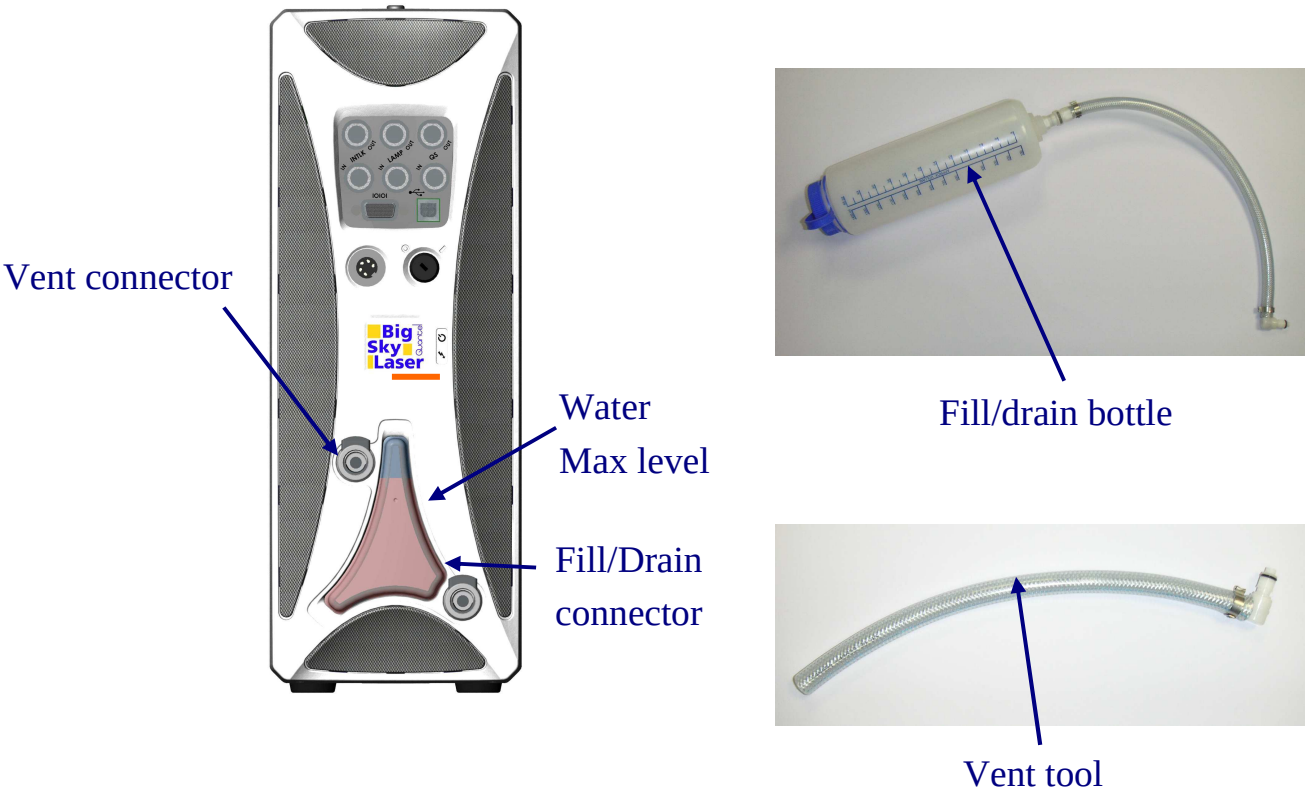


Figure II-3: Water devices

All personnel within the laser working area must wear protective eyewear while the laser is operating. Even small energy levels (microjoules) from an Nd:YAG laser can cause permanent eye damage. The glasses must have the following minimum protection expressed in Optical Density: O.D.

Wavelength (nm)	O.D.	L.
1064	>6	>7
532	>7	>7
355	>3	>6
266	>3	>2
213	>2	>1

The Brilliant EaZy is now ready for use. The operation is given in detail in chapter IV.

If you need to ship the laser or any reason, please drain the system for transport to prevent freezing.

III. LASER DESCRIPTION

III.1. GENERALITIES

The laser consists of two major subassemblies: the Optical Head and the Power Supply. They are connected together by cables, wires, and hoses, running through an umbilical.

The optical head contains all the necessary components for generating the infrared laser beam and optionally, its 2^{nd}, 3^{rd}, 4^{th} and/or 5^{th} harmonics, including wavelength separation package.

The power supply, in addition to energizing the optical head, provides all logical functions necessary to operate the laser, and the cooling capability to dissipate the heat generated in the optical head by the operation of the flashlamp.

Additional safety and flexibility in operating the laser is provided by a remote control box, and an RS232 computer interface.

III.2. THE OPTICAL HEADS

III.2.a. THE OSCILLATOR

The mechanical structure of the oscillator is a precision machined monolithic alloy block temperature-stabilized by a water loop, which ensures alignment and parallelism of the resonator mirrors. The oscillator is a short cavity unstable resonator with a variable reflectivity output mirror (single transverse mode operation), delivering 5-6 ns pulses. The oscillator layout is shown in Draw III-1.and Draw III-2.

The oscillator consists of:

1. A Q-Switch electronics box: no voltage is applied on the Pockels cell, except at the time of opening of the Q-Switch, when a negative high voltage pulse is applied.

2. Trigger transformer which provides high voltage to the flashlamp to initial the flashlamp arc.

3. A high reflectivity mirror at 1064 nm, whose radius of curvature is chosen to provide a low divergence output beam.

4. A Pockels cell, providing the Q-Switch operation together with the quarter-wave plate (3), and the polarizer (6).

5. A phase retardation plate providing the Q-Switch operation together with the Pockels cell (4), and the polarizer (6).

6. A polarizer, which linearly polarizes the light in the cavity.

7. A pumping cavity: composed of a ceramic diffusing chamber (highly homogeneous pump light), a Samarium filter, a Nd:YAG rod with a 6 mm (Brilliant) diameter and 115 mm length. The two faces are anti-reflection (AR) coated. The rod is pumped by one flash. The rod and flashlamp are cooled by a closed loop deionised water flow.

8. A thermal sensor to prevent overheating (on the right side of the cavity).

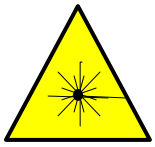
9. A pump cavity cover, which must be removed for changing the flashlamp.

10. An output mirror: mirror with a variable reflectivity coating, decreasing from the centre to the edges. The outer face is AR-coated at 1064 nm.

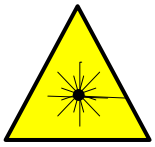
11. A mechanical output beam aperture (diameter 12.5 mm), with counter bore to receive the Second Harmonic Generator module.

12. A guide hole for the connection of the Second Harmonic Generator module.

13. A power supply 9 points connector for the Second Harmonic Generator module.



14. A beam shutter and Q-Switch warning light: this light is on when the beam shutter is in the open position, indicating that a laser beam can be emitted. For Q-Switch operation this indicator will flash until the Q-Switch is stopped.



15. A beam shutter: manual shutter which has two positions. The closed position inhibits the Q-Switch operation and blocks the laser beam trajectory; in this position the warning light (14) is off. The open position enables the Q-Switch operation and the beam output; in this position the warning light (14) is on.

16. A fastening screw for the protective housing. This one has to be unscrewed to take off the protective housing.

17. A rear connector.

18. Fastening legs: the three legs are engineered to match different kinds of optical tables. Paragraph II.3.b.i describes how to use these legs.

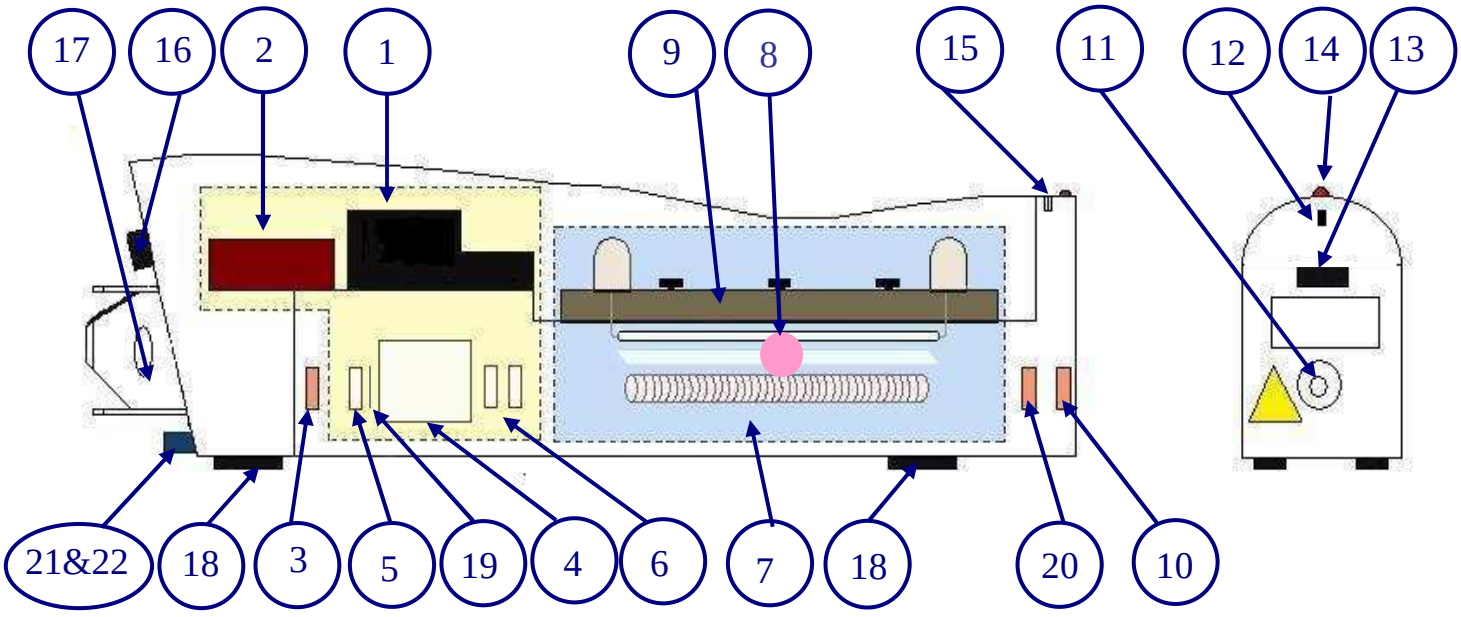
19. A cylindrical diverging lens improving the beam shape.

20. A phase retardation plate may be used at each side of the rod to increase the spatial quality of the beam.

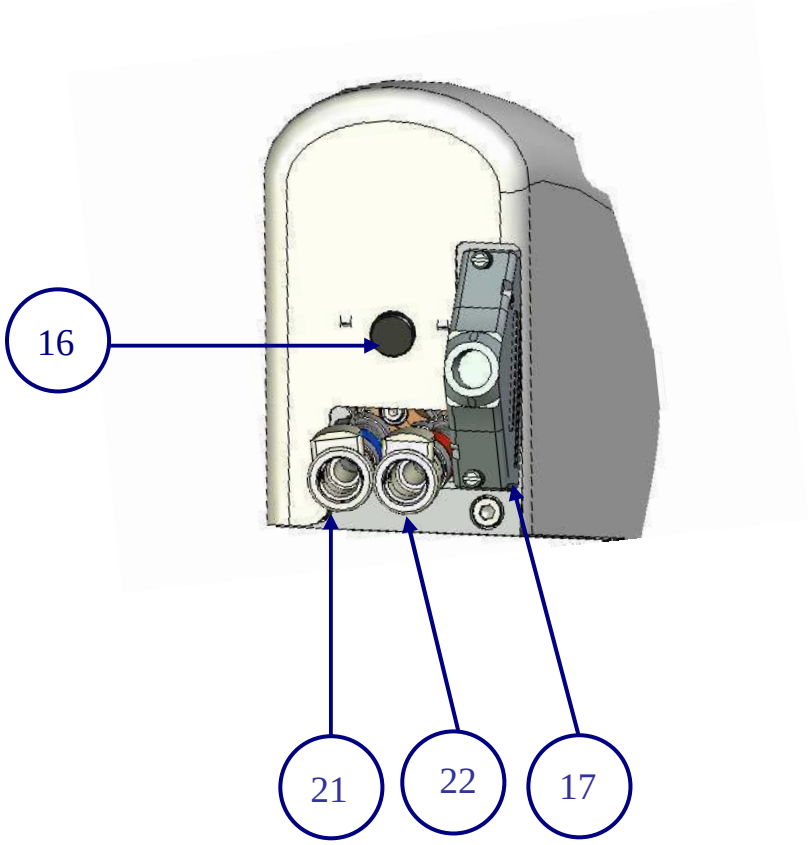
21. Input coolant connector.

22. Output coolant connector.

The cavity is optimized for a fixed flashlamp repetition rate. Severe damages to the components may occur if this repetition rate is changed without consulting QUANTEL or its representatives.



Draw III-1: Diagram for the Brilliant EaZy: Side and front



Draw III-2: Diagram of brilliant EaZy: Back

III.2.b. HARMONIC GENERATION MODULES (OPTIONS)

Brilliant EaZy can generate the fundamental wavelength of Nd:YAG at 1064 nm or its harmonics (532 nm, 355 nm, 266 nm, 213nm). This is achieved by specific modules (2W, 3W, 4W and 5W) easily plugged onto the optical head with no alignment.

The harmonic generation is made with highly deuterated KD*P crystals cut at the proper angle for required wavelengths. Each crystal is temperature stabilized in a sealed-off cell ensuring long term energy stability. Cell windows are anti-reflection coated at the appropriate wavelengths.

Precise mechanical mounts allow to accurately phase-match the 2nd, 3rd and 5th harmonic generators. The 4th harmonic generator is temperature phase-matched. Each generator module includes a set of dichroïc mirrors which isolates the required wavelength and steers the beam toward the output port.

1. A power supply 9 points connector for temperature stabilization of harmonic crystals.

2. An input beam aperture (12.5 mm diameter), surrounded by a circular raised piece to guide the module position when fastening it to the oscillator or to another module.

3. A pin for positioning guide.

4. Four holes to assemble the module to the oscillator or to another module. The required screws and key are delivered with the HGM when ordered separately.

5. A quarter-wave or half-wave plate, for SHG module only.

6. SHG, THG, FoHG or FiHG crystal housing.

7. A phase-matching adjustment screw: used to set the correct phase-matching angle for SHG, THG and FiHG, and the crystal temperature for FoHG.

8. A separation package which consists of a mechanical mount and two dichroïc mirrors:

   - Rmax at 532 nm and Tmax at 1064 nm for SHG module.
   - Rmax at 355 nm and Tmax at 1064 nm and 532 nm for THG module.

- Rmax at 266 nm and Tmax at the other wavelengths for FoHG module.
- Rmax at 213 nm and Tmax at the other wavelengths for FiHG module.

9. A supporting leg: it consists of a screw and a nut to lock it.

10. Labels.

11. A mechanical output beam aperture (diameter 12.5 mm) for wavelengths other than the specified harmonic, and with counter bore to receive other HGM if needed.

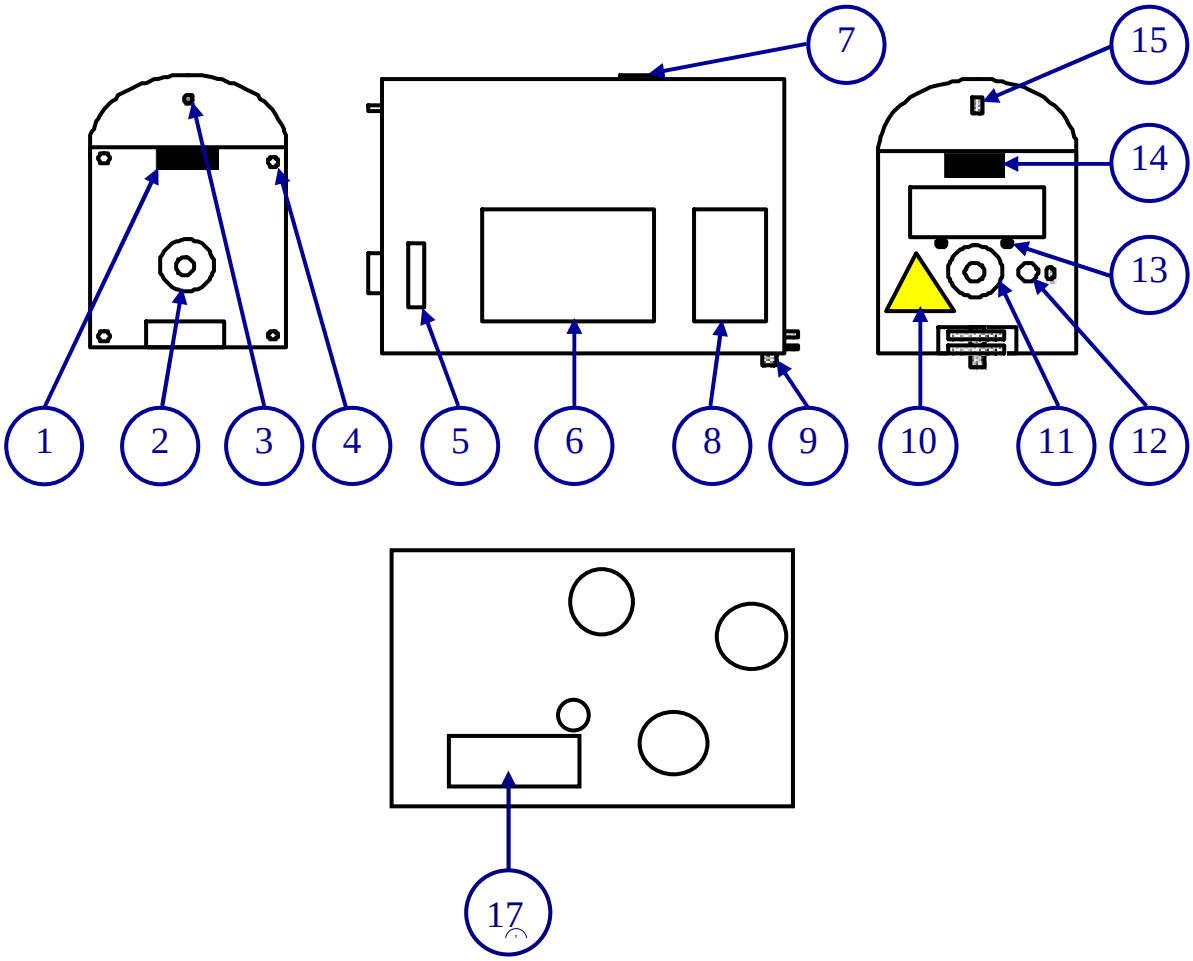
12. A mechanical output beam aperture for the specified harmonic. Before going out of this aperture, the beam has been folded by the two dichroïc mirrors described in (8).

13. Threaded holes for beam dump attachment: whenever wavelengths other than the specified harmonic are not used, a beam dump element (delivered with the HGM) must be tighten on the front face of the HGM with 2 M3 screws (provided).
14. A power supply 9 points connector for other HGM.

15. A guide hole for connection of other HGM.

16. HGM protective housing (not shown on Draw III-3).

17. Electronic board for HGM regulation



Draw III-3 description of harmonic generator

III.2.c. INSTALLATION AND REMOVAL OF HARMONIC GENERATION MODULES

By optical head we mean one of the following laser system combinations:

- Oscillator (1064nm).
- Oscillator + SHG module (532nm).
- Oscillator + SHG module + THG module (355nm).
- Oscillator + SHG module + FoHG module (266nm).
- Oscillator + SHG module + FoHG module+ FiHG module (213nm).

When the user acquires any of these laser systems, the oscillator and other modules are assembled at QUANTEL, and the installation is similar to the oscillator one which has been described in § II-3-a-i.

However, for the system combination Oscillator + SHG module + THG module, the user can operate the laser at 355 nm, at 532 nm by removing the THG module or at 1064 nm by removing the SHG module also. To install or remove a module, the same operations have to be done but in a reverse order. To install or remove the FiHG module proceed in the same manner as for THG or FoHG modules.

III.2.c.i. INSTALLATION OF A SHG MODULE

To assemble the SHG module with the oscillator, please proceed as follows:

1. The laser should be OFF, and the key on the “0” position.

2. Unscrew the four screws of the SHG module protective housing and pull it off.

3. Hold the SHG module and adjust the position guide, elements (2) and (3) of Draw III-3, in front of the corresponding female part of the oscillator, elements (11) and (12) of Draw III-1. Then assemble them together.

4. Insert and tighten the four screws (delivered with the SHG module), see (4) of Draw III-3.

5. Slightly screw the supporting leg (9) of Draw III-3 until it is just in contact with the table, and lock it with the nut.

6. Put back the SHG module protective housing and tighten its four screws.

7. If the user wants to use the second harmonic only, a beam dump (delivered) has to be attached to the front face of HGM, and the HGM is ready for operation.

III.2.c.ii. INSTALLATION OF A THG OR FOHG MODULE

Before assembling THG or FoHG the user has to take off the separation package of the SHG from the module. For this, please proceed as follows:

1. The laser should be OFF, and the key on the “0” position.

2. Remove the beam dump from the front face of the SHG module.

3. Unscrew the four screws of the SHG module protective housing and pull it off.

4. Unscrew the three screws of the plate on the SHG module side.

5. Hold the separation package (tag n°8 of Draw III-3) and unscrew the two screws M4 visible from the top side.

6. Put the separation package in the box (delivered with the SHG module) to preserve it from dust.

7. Put back the plate on the SHG module side and tighten the three screws.

8. Put back the SHG module protective housing and tighten the four screws.

9. Remember, when you put ON the laser you should select the corresponding option 3ω or 4ω with the remote control box through the system info sub menu.

The SHG module is now ready to receive the THG or the FoHG modules. To install one of these modules please proceed exactly as for the SHG module (section a), as the harmonic generators are similar.

III.2.c.iii. REMOVAL OF A THG OR FOHG MODULE

To remove a THG or FoHG module from the optical head, please proceed as follows:

1. The laser should be OFF, and the key on the “0” position.

2. Unscrew the four screws of the THG module's protective housing and pull it off.

3. Hold the THG module and unscrew the four screws that hold the THG to the SHG (tag n°4 of Draw III-3). Pull the THG module off. Keep the screws with the module.

4. Put back the THG module's protective housing and tighten its four screws.

Before operating the SHG, the user has to put back the separation package of the SHG in its module. For this, please proceed as follows:

5. Unscrew the four screws of the SHG module's protective housing and pull it off.

6. Unscrew the three screws of the plate on the SHG module side.

7. Take the separation package out of its box and hold it with its finger print. Push the separation package inside until the two holes are just below the corresponding ones in the module, visible from the top side. Insert and tighten the two M4 screws.

8. Put back the plate on the SHG module side and tighten the three screws.

9. Put back the SHG module protective housing and tighten the four screws.

10. If the user wants to use the second harmonic only, the beam dump (delivered) has to be attached to the front face of HGM, and the HGM is ready for operation.

The SHG module is now ready for operation.

III.2.c.iv. REMOVAL OF A SHG MODULE

To remove the SHG module from the optical head, please proceed as follows:

1. The laser should be OFF, and the key on the “0” position.

2. Unscrew the four screws of the SHG module's protective housing and pull it off.

3. Hold the SHG module and unscrew the four screws that hold the SHG to the laser, see (4) of Draw III-3. Pull the SHG module off. Keep the screws with the module.

4. Put back in place the SHG module's protective housing and tighten its four screws.

Optical elements or HGM have to be kept dry and out of dust to avoid degradation of optical coatings.

III.3. THE ELECTRONIC CABINET

III.3.a. GENERAL DESCRIPTION

The power supply cabinet contains all necessary hardware to control power and cool the optical head. The Integrated Cooling and Electronics (ICE) can be divided into two subsystems: the Power Supply Unit (PSU) with a Remote Control box (RC) and the Cooling Group Unit (CGU). The ICE is connected directly to the main power line. Each individual subsystem is then connected to the main power line through a bus located inside the ICE.

III.3.a.i. POWER SUPPLY UNIT DESCRIPTION

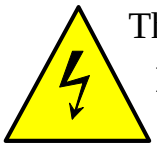
The PSU consists of three subassemblies packaged inside the ICE.

- Charger/Simmer board : to charge the capacitor bank, storing energy for the flashlamp discharge, and to maintain a low "simmer" current between the pulses in order to decrease E.M.I. noise and improve the lifetime of the lamp.

- Control board :

  - to control the timing of charge and fire orders
  - to operate the laser in Manual, Automatic or External mode
  - to monitor security interlocks (switch the laser off when a malfunction is detected).

- I/O board: which provides a user interface for control, and for safety and timing signals in the ICE.



The power supply including the capacitor bank is a potentially lethal unit. **Never attempt to make alterations or repairs on this unit or on the cooling group unit without consulting QUANTEL.**

III.3.a.ii. COOLING GROUP UNIT DESCRIPTION

The cooling group is an independent unit located inside the ICE. It cools the flashlamp and the rod with a closed loop of de-ionized coolant. This temperature regulated coolant also provides thermal stabilization of the oscillator's structure.

Cooling of the demineralised coolant is achieved by a liquid to air stainless steel exchanger.

Thermal stabilization of the coolant is achieved by a thermostatic electronic circuit which regulates the fan's speed and consequently the air flow rate through the exchanger. The temperature stabilization is within ± 1 °C. The ambient air temperature can range from 18 °C to 28°C with no consequence on the laser operation.

In the closed loop, to maintain the coolant resistivity > 1MOhm/cm, a pick-off shunt deviates part of the coolant from the heat exchanger into a de-ionization cartridge. The de-ionized coolant comes back directly into the tank. The CGU has coolant level, flow-sensing and heat-sensing switches to interlock with the power supply unit, to prevent damage to the laser head in case of a cooling system failure.

The CGU requires 1.5 liters (0.4 US gal.). For the maintenance of the CGU please refer to chapter V.

III.3.a.iii. REAR AND FRONT PANEL DESCRIPTION

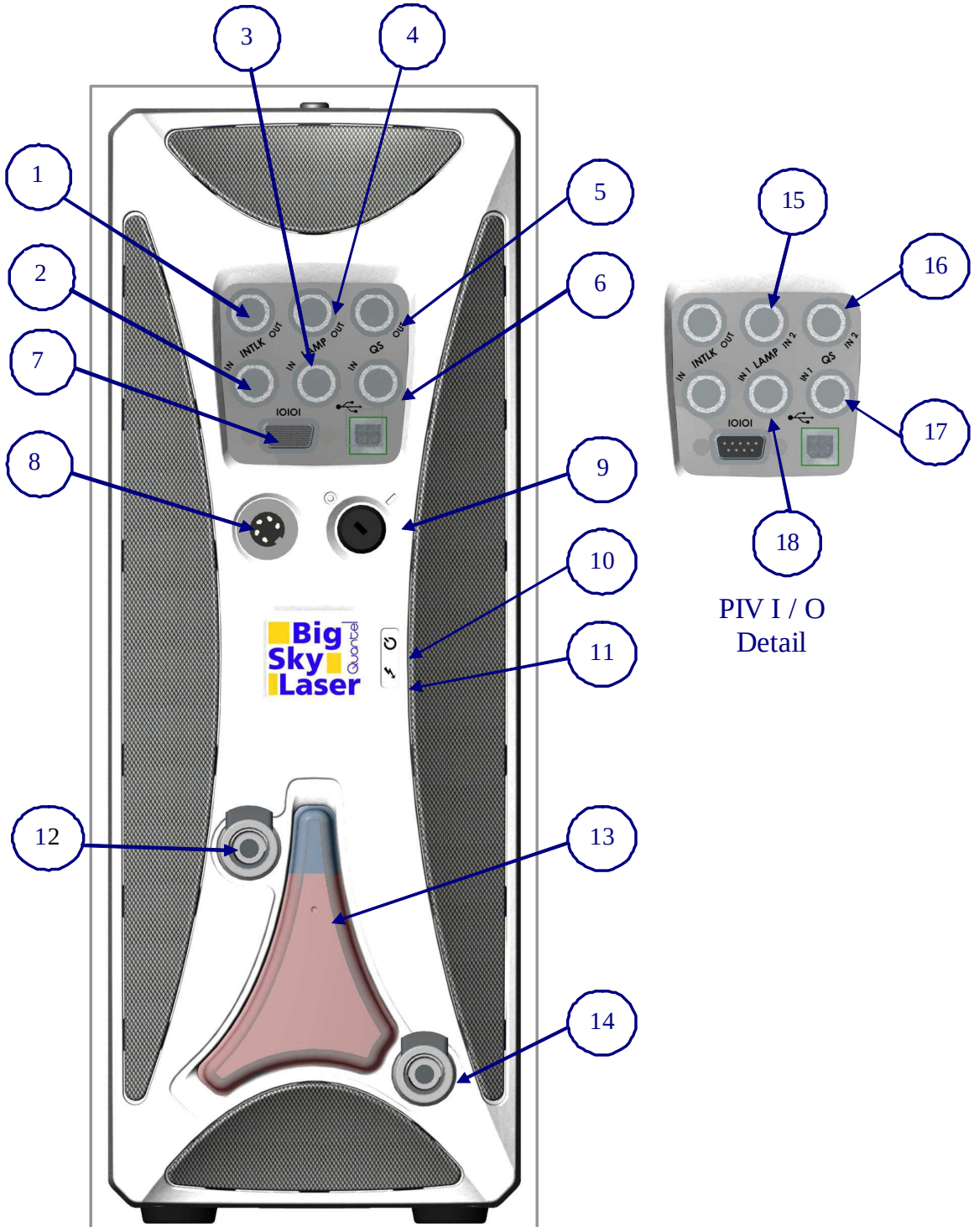


Figure III-1: Front panel description

1. **Interlock Out:** (BNC Connector) allows the user to interface to an external Laser Warning Indicator. Output is low (pulled to ground) when the laser is disabled. Output goes to +15 VDC and is capable of providing up to 150mA when the laser high voltage is enabled. CAUTION: This output is not short circuit protected.
2. **Interlock In:** (BNC Connector) allows the user to interface to an external safety shutdown switch. This connector must be shorted to allow the laser to operate. If an open circuit is detected, the laser power supply high voltage is disabled and the PFN capacitor is discharged in less than 5 seconds. If multiple safety switches are employed, they must be connected in series. Ensure that the attached BNC shorting cap is installed on this connector if this function is not needed.
3. **Lamp In:** (BNC Connector) provides external synchronization of the flashlamp fire order when External Flashlamp Trigger Mode is selected via the Remote Box or serial interface. The trigger source must be capable of supplying a pulse with the following characteristics: Amplitude: $+5V_{NOM}$ into 50 ohms, Pulsewidth: 10µs to 100µs as described on figure III-2

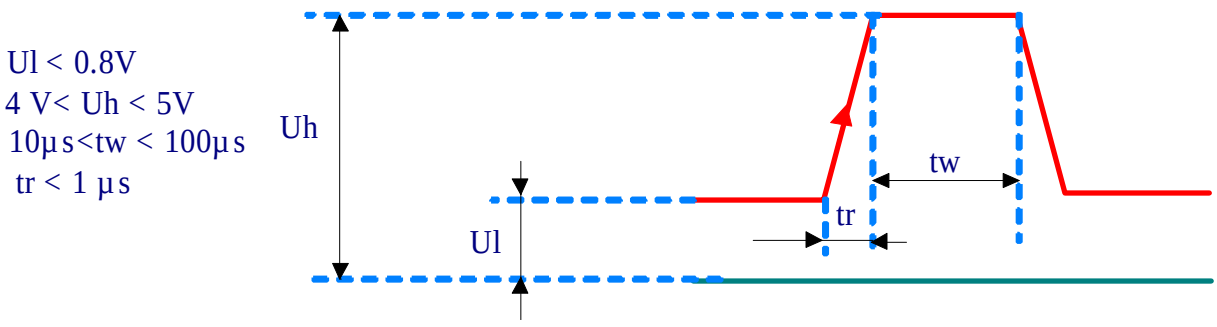


Figure III-2: Characteristics of the input signal for flashlamp synchronization

4. **Lamp Out:** (BNC Connector) Allows synchronization to the laser flashlamp trigger signal. This order corresponds to the rising edge of a positive TTL signal (5V, 20 mA max, 50 µS duration).
5. **Q-Switch Out:** (BNC Connector) Allows synchronization to the laser Q-Switch trigger signal. This order corresponds to the rising edge of a positive TTL signal (5V, 20 mA max, 10 µS duration).
6. **Q-Switch In:** (BNC Connector) Provides external synchronization of the Q-Switch trigger when External Q-Switch Trigger Mode is selected via the Remote Box or serial interface (please refer to IV.1.C.i). The trigger source must be capable of supplying a pulse with the following characteristics: Amplitude: $+5V_{NOM}$ into 50 ohms, Pulsewidth: 10µs to 100µs.All the features are described on Figure III-3. The minimum Q-Switch trigger delay must be 150 +/- 1 µsec with respect to the flashlamp trigger (as measured on the Lamp Out Connector). Triggering the Q-Switch with a shorter delay may result in double pulsing of the laser, which damage the optics. Triggering the Q-Switch with a longer delay will attenuate the laser output (see chapter IV.1.b.i).

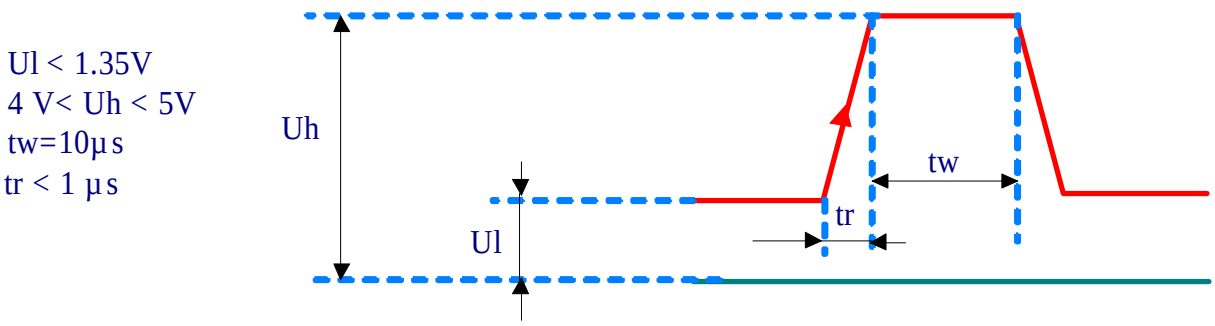


Figure III-3: Characteristics of the input signal for Q-Switch synchronisation

7. **Computer Serial Port Interface (RS-232):** (DE-9S. D-Sub Connector) Allows the laser system to be operated by remote computer control via standard RS-232 interface. The port configuration and command set are detailed in chapter III.3.a iii. Computer control is disabled if you toggle one of the Remote Box button.
8. **Remote Box Interface (RB):** (DIN Connector) All operating parameters and settings for laser control can be accessed when the Remote Box is connected to the laser power supply.
9. **Power Key Switch:** When rotated to the "I" position, AC line power is switched ON, allowing the laser system to be operated. The key is not removable in the "I" position. To turn the laser power supply OFF, rotate the key to the "O" position. The key may be removed to keep unauthorized personnel from operating the laser.
10. **Power ON Indicator:** Indicator illuminates when the Key Switch is turned ON and the Mains are plugged into 85 – 264VAC 50/60 Hz. The indicator is Amber in color to ensure visibility through laser goggles.
11. **Laser ON Indicator:** Indicator illuminates when high voltage is being charged in the capacitor. The indicator is Amber in color to ensure visibility through laser goggles. When this indicator is illuminated, the user is warned to observe laser safety precautions as described in chapter I of this manual.

12. **Reservoir Vent Port:** The vent port allows pressure equalization in the Cooling System when coolant is added or drained. Refer to the Fill and Drain procedures in chapter one of this manual for detailed instructions.
13. **Minimum Coolant Level Indicator:** This depression on the front of the coolant reservoir indicates the recommended minimum coolant level, whether the system is mounted horizontally or standing vertically. The reservoir is backlit with dual color LED's for improved coolant level visibility. When the coolant drops below the minimum level, the level interlock trips to inhibit laser operation and the reservoir backlight flashes to notify the user to add coolant.
14. **Reservoir Fill/Drain Port:** This is the port through which coolant is added or drained.
15. **PIV Lamp #2 In:** (BNC Connector) Provides external synchronization of the flashlamp fire order for the second laser head of a PIV laser pair when External Flashlamp Trigger Mode is selected via the Remote Box or serial interface. The trigger source must be capable of supplying a pulse with the following characteristics: Amplitude: $+5V_{NOM}$ into 50 ohms, Pulsewidth: 10µs to 100µs as described in figure III-4.
16. **Q-Switch #2 In:** (BNC Connector) Provides external synchronization of the Q-Switch trigger for the second laser head of a PIV laser pair when External Q-Switch Trigger Mode is selected via the Remote Box or serial interface. The trigger source must be capable of supplying a pulse with the following characteristics: Amplitude: $+5V_{NOM}$ into 50 ohms, Pulsewidth: 10µs to 100µs. The Q-Switch trigger must be delayed by 150 µS +/- 1 µsec with respect to the flashlamp #2 trigger (as described in figure III-21). Triggering the Q-Switch with a shorter delay may result in double pulsing of the laser. Triggering the Q-Switch with a longer delay will attenuate the laser output.

17. **Q-Switch #1 In:** (BNC Connector) Provides external synchronization of the Q-Switch trigger for the first laser head of a PIV laser pair when External Q-Switch Trigger Mode is selected via the Remote Box or serial interface. All other characteristics are identical to **Q-Switch #2 In**
18. **PIV Lamp #1 In:** (BNC Connector) Provides external synchronization of the flashlamp fire order for the first laser head of a PIV laser pair when External Flashlamp Trigger Mode is selected via the Remote Box or serial interface. All other characteristics are identical to **PIV Lamp #2 In**.

III.3.b. COMMUNICATION

III.3.b.i. THE RS232 PROTOCOL

The host computer has to incorporate an RS 232 command format, and the cable to the ICE should not exceed 20 m. The standard wiring diagram is shown on figure III-4. All wires must be present.

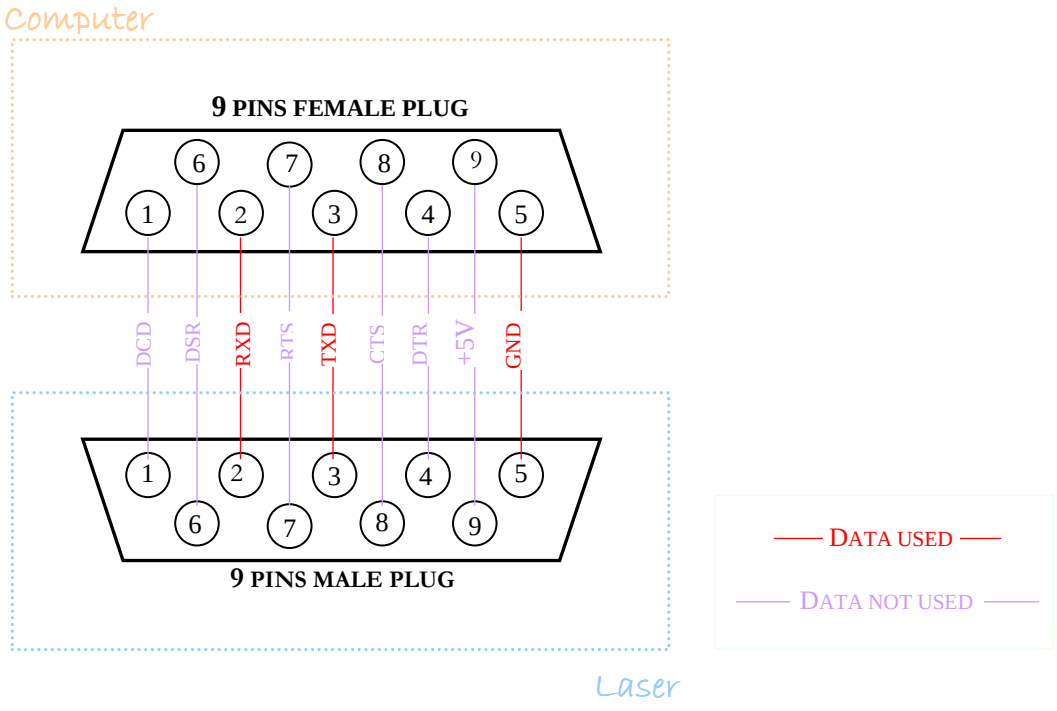


Figure III-4

Commands are in ASCII string, upper case only, and must be terminated by Carriage Return Line Feed character "CRLF" or “LF”. The RS 232 communication parameters are :

- 9600 BAUD, 8 Bit, 1 Stop Bit, No Parity.

The commands via RS232 can be sent with maximum rate of 20Hz. The connection is working in half duplex without Xon, Xoff and RTS CTS.

If the sent character chain is not identified, the answer is **unknown char**.

During programming of data, if the number is out of range, then the answer is **overflow char**.

If the expected character is numeric and the entered one is not, then the answer is **not num. char**.

The following commands can be used to control the operation of the **Brilliant EaZy**. Note that the answer consists of "CRLF" followed by 15 characters. For a better visibility, the space character is replaced by "°"

III.3.b.ii. CONFIGURATION PARAMETERS

COMMAND	DESCRIPTION	ANSWER
X "CRLF"	Software revision used	BRILLIANT°°°°00.00
DAT "CRLF"	Date of software revision *Date/month/year*	--/--/--°°°°°°°
CGT"CRLF"	Reads the cooling group temp (°C)	temp.°CG°--°d°°
CGF"CRLF"	Reads the cooling group temp (°F)	temp.°CG°---°F°
HGT"CRLF"	Reads NLO Crystal temp (°C)	temp °NLO--°d°°
CST"CRLF"	Reads Simmer Board temp. (°C)	temp °SIM--°d°°
CSF "CRLF"	Reads Simmer Board temp. (°F)	temp °SIM--°F°°
NTP "CRLF"	Reads type of display (°C or°F)	option°TP°°:°°-
CFG "CRLF"	Reads the current configuration	configuration°-
T"CRLF"	Time counter hhhh = number of hours mm = number of minutes	ct°time°hhhh:mm

COMMAND	DESCRIPTION	ANSWER
CFG1”CRLF”	Loading a new configuration	configuration°1 Valid range: 1 – 4
SAV2”CRLF”	Saving the current configuration	Save°config.°°2 Valid range: 1 – 4
NTP1"CRLF"	Sets temperature display in °F	option°TP°°:°°1 Valid range: 0 – 1 (0 = °C, 1 = °F)
WOR"CRLF"	Status of laser	I°a°F°b°S°c°Q°d

	0	1	2	4	5	6
a: Interlock	ok	fail	-	-	-	-
b: Flashlamp	stop	single	start	stop	single	start
	Internal synchro			External synchro		
c: Simmer	off	on	-	-	-	-
Q-Switch (d)	stop	single	start	stop	single	start
	Internal synchro			External synchro		

Table III.1: Laser status

COMMAND	DESCRIPTION	ANSWER
"CRLF"	Reads the status of the lamp & QS	see lamp & QS
	operating mode	prog& activation

III.3.b.iii. FLASHLAMP PARAMETERS

COMMAND	DESCRIPTION	ANSWER
V"CRLF"	Flashlamp voltage (V)	voltage°°----°V
D"CRLF"	Pre-set repetition rate (Hz)	freq.°°--.--°Hz
F"CRLF"	Lamp shot counter (9 digits)	ct°LP°---------
UF"CRLF"	Lamp User's shot counter (9 digits)	cu°LP°---------

COMMAND	DESCRIPTION	ANSWER
V620"CRLF	Set Flashlamp voltage (V)	voltage°°0620°V
UF0"CRLF"	Reset Lamp User's shot counter	cu°LP°000000000

COMMAND	DESCRIPTION	ANSWER
A "CRLF"	Activates automatic fire of lamp in the preselected operating mode:	
	lamp in internal triggers &Q-S programmed in internal trigger	fire°auto°°°°°°
	lamp in internal trigger & Q-S programmed in external trigger	fire°auto°°°°e°
E"CRLF"	Activates automatic fire of lamp in the preselected operating mode	fire°ext°°°°°°°
	lamp in external trigger & Q-S	

	programmed in internal trigger	fire°ext°°°°°e°
	lamp in external trigger & Q-S programmed in external trigger	
S"CRLF"	Stops automatic internal or external lamp firing	
	Q-S programmed in internal trigger	standby°°°°°°°°
	Q-S programmed in external trigger	standby°°°°°°e°
M"CRLF"	Set the lamp on Simmer in the preselected operating mode	
	lamp in internal trigger & Q-S programmed in internal trigger	simmer°°°°°°°°°
	lamp in internal trigger & Q-S programmed in external trigger	simmer°°°°°°°e°

III.3.b.iv. Q-SWITCH PARAMETERS

COMMAND	DESCRIPTION	ANSWER
QSM"CRLF	Read Q-S mode (see QSM programming)	QS°mode° :°°°-°°
QSF"CRLF"	Read Q-S re rate F/n in auto mode	QS°reprate°F/--
QSP"CRLF"	Read Q-S number of pulses in burst mode	burst°QS°°°°---
Q "CRLF"	Read Q-S parameter in scan mode	QS°°°--°°--°°--
FQ "CRLF"	Q-Switch shot counter (9 digits)	ct°QS°---------
UFQ "CRLF"	Q-S User's shot counter (9 digits)	cu°QS°---------
W "CRLF"	Delay between flashlamp & Q-S	delay°°°°---°uS

WD "CRLF"	Delay between Q-S1 & Q-S2 Only for double pulse option	QS1-QS2°°---°uS

Command	Description	Answer
QI"CRLF"	Sets internal Q-S synchro mode in the preselected operating mode	QS°synch°:°°int
QE"CRLF"	Sets external Q-S synchro mode in the preselected operating mode	QS°synch°:°°ext
QSM1"CRLF	Sets Q-S mode Auto = 0, Burst = 1 and Scan = 2	QS°mode° :°°°1°°
QSF10"CRLF"	Set Q-S rep rate at F/10 F/n should be an integer	QS°reprate°F/10
QSP50"CRLF"	Sets Q-S operation in burst mode of 50 shots Valid range: 1 to 999	burst°QS°°°°050

Q120455"CRLF"	Sets the number of pulses in scan mode. *In this example:* *firing is inhibited for 12 shots,* *firing is authorized for 04 shots,* *the sequence is repeated 55 times.* *For continuous mode operation,* *replace 55 by 99.* *Valid range : 00 01 01 to 99 99 99*	QS°°°12°°04°°55
UFQ0"CRLF"	Reset Q-Switch User's shot counter	cu°QS°000000000
W225 "CRLF"	Sets QS-Flash delay in µs Wmin < W< Wmax (factory set limits)	delay°°°°225°uS
WD100 "CRLF"	Sets delay between Q-S1 & Q-S2 Valid range: 30µs to 250 µs with the double pulse option	QS1-QS2°°100°uS

COMMAND	DESCRIPTION	ANSWER
CC"CRLF"	Start Q-Switch laser emission in the pre-selected operating mode :	
	lamp activated in internal trigger & Q-S activated in internal trigger	fire°auto°°°qs°°
	lamp activated in internal trigger & Q-S activated in external trigger	fire°auto°°°qse
	lamp activated in external trigger & Q-S activated in internal trigger	fire°ext°°°°qs°°
	lamp activated in external trigger & Q-S activated in external trigger	fire°ext°°°°qse°
OP"CRLF"	Single pulse Q-S laser emission in the pre-selected operating mode	
	lamp activated in internal trigger & Q-S activated in internal trigger	fire°auto°°°qs°°
	lamp activated in internal trigger & Q-S activated in external trigger	fire°auto°°°qse°
	lamp activated in external trigger & Q-S activated in internal trigger	fire°ext°°°°qs°°
	lamp activated in external trigger & Q-S activated in external trigger	fire°ext°°°°qse°

III.3.b.v. SAFETY DEVICES

IF"CRLF" Test all series of flashlamp safety interlock ***IF.°00°00°00°00***

COMMAND	DESCRIPTION	ANSWER
IF1"CRLF"	Safety interlocks state 1.	
emergency stop push button activated		*IF1°10°00°00°00*
external safety interlock defeated (BNC in the front panel of the ICE)		*IF1°01°00°00°00*
laser head T° > than 45°C		*IF1°00°10°00°00*
laser protective housing not closed		*IF1°00°01°00°00*
ICE protective housing not closed		*IF1°00°00°10°00*
Controller bus error		*IF1°00°00°01°00*
Flashlamp timeout delay expired		*IF1°00°00°00°10*
IF2"CRLF"	Test second series of flashlamp safety interlock	
Heater above limit temperature		IF2°10°00°00°00
Charger/simmer board over temperature		IF2°01°00°00°00
Firing authorization coolant Temp° below than the preset value		IF2°00°10°00°00

Coolant temp° of the laser above than the preset value	IF2°00°01°00°00
Low coolant level in ICE cooling	IF2°00°00°10°00
Low coolant flow in cooling system	IF2°00°00°01°00

COMMAND	DESCRIPTION	ANSWER
IF3"CRLF"	Test third series of flashlamp safety interlock	
PSU charge error		*IF3°10°00°00°00*
Flashlamp voltage higher than normal setting.		*IF3°01°00°00°00*
simmer failed		*IF3°00°10°00°00*
rep rate of lamp in external synchro below the preset value		*IF3°00°01°00°00*
rep rate of lamp in external synchro above the preset value		*IF3°00°00°10°00*
Capacitor remains above 100V after firing		*IF3°00°00°01°00*
Simmer timeout delay expired		*IF3°00°00°00°10*

.

IQ"CRLF"
Test Q-Switch safety devices: ***IQS°00°00°00°00***

COMMAND	DESCRIPTION	ANSWER
IQ"CRLF"	Q-Switch safety interlocks state.	
	Emission inhibited following flashlamp activation.	IQS°10°00°00°00
	laser coolant Temp° below than the preset value.	IQS°01°00°00°00
	Q-Switch stop (end of time out).	IQS°00°10°00°00
	Manual shutter closed.	IQS°00°00°00°10

INTERLOCK	PROBLEM DESCRIPTION	MESSAGE
Flashlamp	Emergency push button	Emergency p-b
Flashlamp	BNC Interlock input	BNC intlk in
Flashlamp	Laser head temperature too high.	head overtemp
Flashlamp	Laser head protective housing.	head housing
Flashlamp	ICE housing opened	ICE housing
Flashlamp	Controller bus error	Bus error
Flashlamp	Flashes Timeout delay expired	timeout expired
Flashlamp	Heater temperature too high	heater overtemp
Flashlamp	Charge/simmer temp. too high	charge overtemp
Flashlamp	Low coolant temperature	low coolant temp

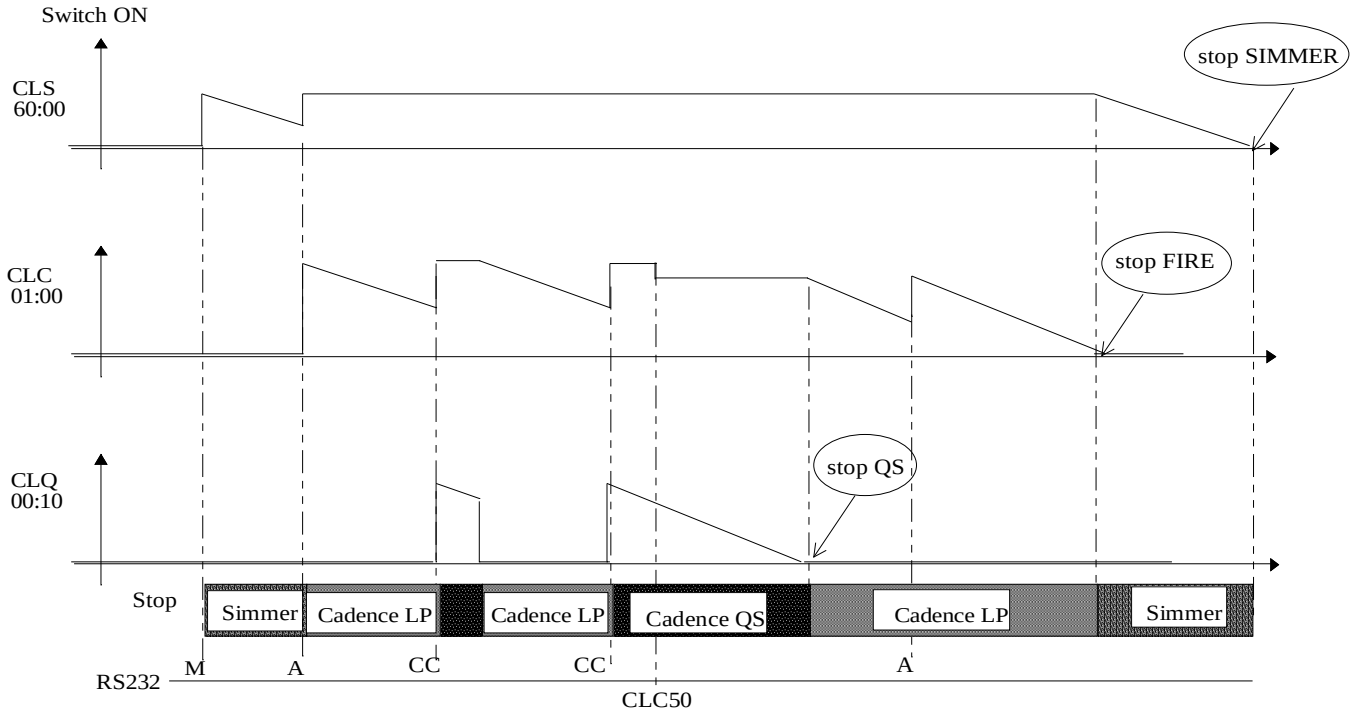
Flashlamp	High coolant temperature	high coolant temp
Flashlamp	Coolant level too low	low coolant level
Flashlamp	Coolant flow too low	low coolant flow
Flashlamp	PSU Charge error	PSU charge err.
Flashlamp	Capacitor voltage > preset	cap overvoltage
Flashlamp	Simmer Stop	simmer stop
Flashlamp	Low frequency on flash trigger	low frequency
Flashlamp	High frequency on flash trigger	high frequency
Flashlamp	Capacitor voltage> 100V after disc	thyristor disc.
Flashlamp	Simmer timeout expired	simmer timeout

Interlock	Problem description	Message
Q-Switch	*wait n pulses following flashlamp*	*please wait 8s activation*
Q-Switch	*Temp° below than the preset value*	*coolant temp*
Q-Switch	*Q-switch stop : end of time out*	*timeout expired*
Q-Switch	*Manual shutter closed*	*shutter closed*

III.3.c. FUNCTION TIME OUT

(reading)

The following data are presented in “minutes : seconds” with 99:59 maximum values.



COMMAND	DESCRIPTION	ANSWER
L”CRLF”	Time out status	time°out°°°°°°-
CLS”CRLF”	Simmer counter order.	con°SIM°=°--:--
CLC”CRLF”	Firing counter order.	con°LF°°=°--:--
CLQ”CRLF”	Q-Switch counter order.	con°QS°°=°--:--
LS”CRLF”	Reads the current simmer counter.	cpt°SIM°=°--:--
LC”CRLF”	Reads the current repetition rate counter.	cpt°LF°=°--:--
LQ”CRLF”	Reads the current Q-Switch counter.	cpt°QS°=°--:--

(Programming)

COMMAND	DESCRIPTION	ANSWER
L1”CRLF”	Sets time out function. Value: 0 or 1	time°out°°°°°°1
CLS6000”CRLF”	Sets value of the simmer counter.	con°SIM°=°60:00
CLC100”CRLF”	Sets value of the firing counter.	con°LF°°=°01:00
CLQ500”CRLF”	Sets value of the Q-Switch counter.	con°QS°°=°05:00

III.3.d. THE REMOTE BOX PROTOCOL

III.3.d.i. DESCRIPTION

The functions on the Remote control Box (RB) provide:

- Flashlamp firing in single shot or automatic
- The choice between internal or external synchronization of the flashlamp
- Flashlamp voltage
- Flashlamp shot counter and user shot counter
- The choice between internal or external synchronization of the Q-switch
- Activation or inhibition of the Q-switch in single shot, automatic and burst mode
- Q-switch shot counter and user shot counter

- Adjustable delay of the output synchronization signal with respect to opening of the Q-switch

- Delay between flashlamp and Q-switch firing

The RB is connected to the ICE front panel through a DIN connector with three meters long flexible: ((8) of figure III-1).

Once the key in the front face of the PCC is turned on "I", control of the laser operation is made via the Remote Control box (RB) if the operator activates any button on it. Figure III-5a shows this RB and the functions available from it.

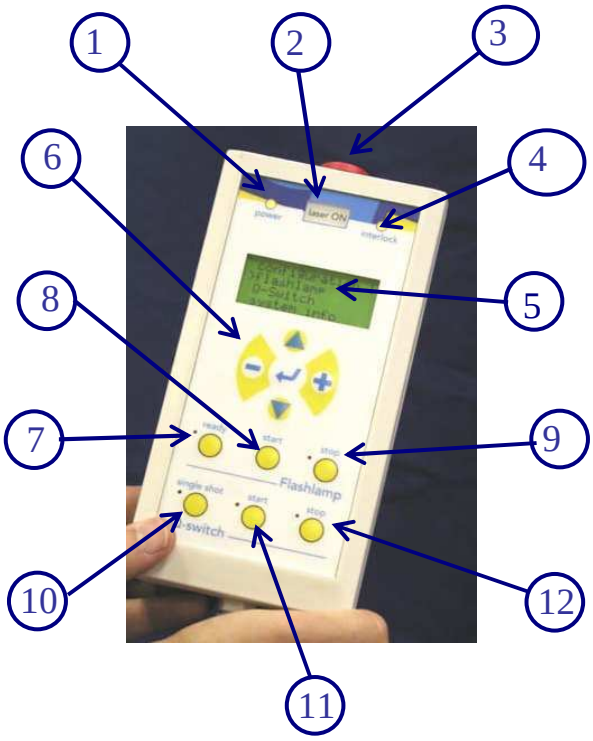
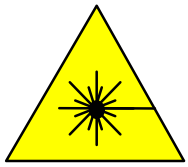


Figure III-5a: Remote Control Box

1. **“Power” led:** this light is up (orange) when the main power line is connected and the turn-on key is on the "I" position.



2. “**Laser ON” inscription:** It lights up (orange) when the flaslamps are operating (flashing or simmer current). It warns the user to observe laser safety precautions (see chapter I).

3. **Emergency Stop push button:** When this button is pushed the PSU stops and capacitor banks are grounded in less than 5s. Pull it before re-operating the system.

4. **“Interlock” led:** It lights up (orange) when the turn-on key is switched to the "I" position and all securities are completed. When a security malfunction is detected, the PSU stops and capacitor banks are grounded in less than 5s, and the orange indicator flashes. A message displayed on the screen ((5) of fig III.5a) indicating the interlock detected. If the malfunction is corrected, the indicator lights up again and the PSU becomes operative. The following safety interlocks may detect a malfunction :
    - Emergency stopping push-button (3) of fig III-5a
    - External safety interlock (2) of fig III-1
    - Thermal sensor (8) of draw III-1
    - Protective housing (16) of draw III-1
    - Thermal-sensor : located in the CGU (see § III.3.a.ii)
    - Flow rate-sensor : located in the CGU (see § III.3.a.ii)

5. **Screen**

6. **Screen display** and buttons to select and validate laser operating parameters:

    - Internal or external synchronization of the flashlamp

- Flashlamp voltage
- Flashlamp frequency (9Hz to 11Hz)
- Flashlamp shot counter and user shot counter
- Internal or external synchronization of the Q-switch
- Activation or inhibition of the Q-switch in single shot, automatic and burst mode
- Delay between flashlamp and Q-switch firing
- Harmonic Generator control activation

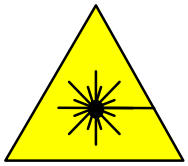
7. **Flashlamp "ready" button:** this button has two functions:

   a. After turning on the key (1) at the front panel of ICE, and when the laser temperature has reached the preset value, pushing this button will fire a single discharge in the flashlamp and starts the Simmer current, and the ready indicator lights up**.**

   b. If the ready indicator is lit up, pushing this button will fire a single discharge in the flashlamp (manual operation).

8. **Flashlamp "start" button:** when the laser temperature has reached the preset value, push this button to fire the flashlamp automatically (lights up its indicator). The charge and fire orders are internally generated.

9. **Flashlamp "stop" button:** push this button to stop the automatic firing or the simmer current of the flashlamp and its indicator lights up.



When the beam shutter light warning ((14) Draw III-1) lights-up and the flashlamp is operating, pushing the following buttons will be followed by laser pulse emission.

10. **Q-Switch single shot:** when the laser temperature has reached the preset value, and if the Q-switch start indicator is not flashing, push this button allows a single pulse operation.

11. **Q-Switch start:** this button allows the operation of the Q-switch in an automatic mode, whatever the Q-switch triggering source is (external or internal). When the laser temperature has reached the preset value, after pushing this button, its indicator and the beam shutter light warning ((14) Draw III-1) will flash until you stop the Q-switch.

12. **Q-Switch stop:** push this button to stop the automatic firing of the Q-Switch operation.

III.3.d.ii. PROTOCOL

The main menu displayed on the screen is:

QUANTEL
name of laser
date of software
version of software

Press **ENTER** ((17) of Fig III-5b**)** to display the main menu**:**

Configuration
>flashlamp
Q-Switch
system info
Save1

To select the desired submenu, toggle the buttons (13) or (14) to move down or up the arrow (>).
To go thought a submenu, press ENTER (17).

To select a parameter or an operating condition, point the arrow (>) on it.

To modify a numeric value, toggle the buttons (15) & (16) for slow change or press them for fast variation.

To switch a non numeric operating condition, toggle the buttons (15) & (16).

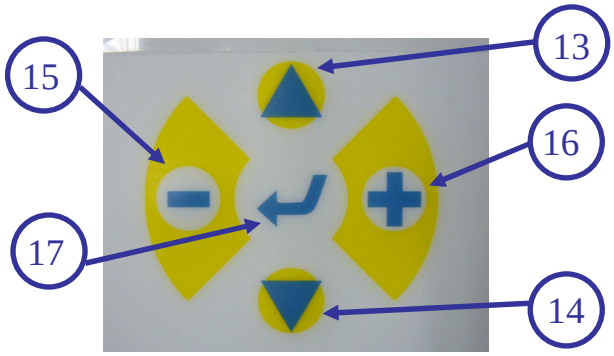


Figure III-5b: Remote Control Box

III.3.d.iii. OPERATING CONDITIONS

- Serial link **on** or **off**: the off position inhibits any modification of the laser parameters coming through the RS232 serial port, while reading the status is not affected.

- Synchro **internal** or **external**: the operating condition can be switched from internal synchronisation to the external one for the flashlamp or the Q-switch.

- Q-switch mode auto, burst or scan: select the mode with the buttons (15) & (16) of Fig III-5b and press ENTER (17) to access the mode modification. When the auto mode is validated, the Q-switch operates continually, and the user can choose the repetition rate F,or F/n (n is an integer, F is the repetition rate). The burst mode is used when the user would like to fire a successive given number of laser shot. The scan mode is used when the user would like to repeat many times the burst mode. If the burst or the scan mode is activated, another menu is displayed and you can modify the operating

condition. To validate any modification in the Q-switch mode, you must stop Q-switch and start it again.

III.3.d.iv. ADJUSTABLE PARAMETERS

- Flashlamp voltage xxxxV: the user can adjust the pump energy in the flashlamps if required. To avoid free-running operation in the laser, the High Voltage variation has a limited range.

- Fl-QS delay xxx µs: the user can adjust the time delay between flashlamp and the Q-switch fire order and the output energy of the laser will decrease as this delay move away from the optimal value. The optimal value is set during laser optimisation in Quantel.

- Q-switch repetition rate: (operating conditions above).

- Time out: this function allows the user to stop automatically the Q-Switch, Flashlamp or the Simmer current when they exceed an active time duration. These parameters are independent, for example you may stop the Simmer current after 5 minutes if no flashlamp order is received. The flashlamp may be stopped automatically 10 minutes after the last Q-switch fire order. The Q-switch may be stopped automatically 2 minutes after the last Q-switch fire order. If you stop before the end of the time out, when you start again the counter restart from your initial parameters that you entered.

- Pump: Activate or not the pump. “Fill” mode allow more time before the pump shuts off due to the level or flow coolant reservoir

When you stop the flashlamp, all set modifications are loaded in the system memory. This stored configuration is automatically set when you turn the laser ON.

To access the operating conditions and adjustable parameters, figure III-6 presents schematic diagram of the different menu provided by the RB. To go from a menu to another please press the ENTER button.

III.3.d.v. SAVE CONFIGURATION

Parameters used for the operation of the laser can be saved. Four different configurations 1 to 4 are available for this.

The RB is also used to display an error messages when at least one of the safety devices interlock is defeated. Details on the error messages and solution are presented in Chapter VI TROUBLESHOOTING.

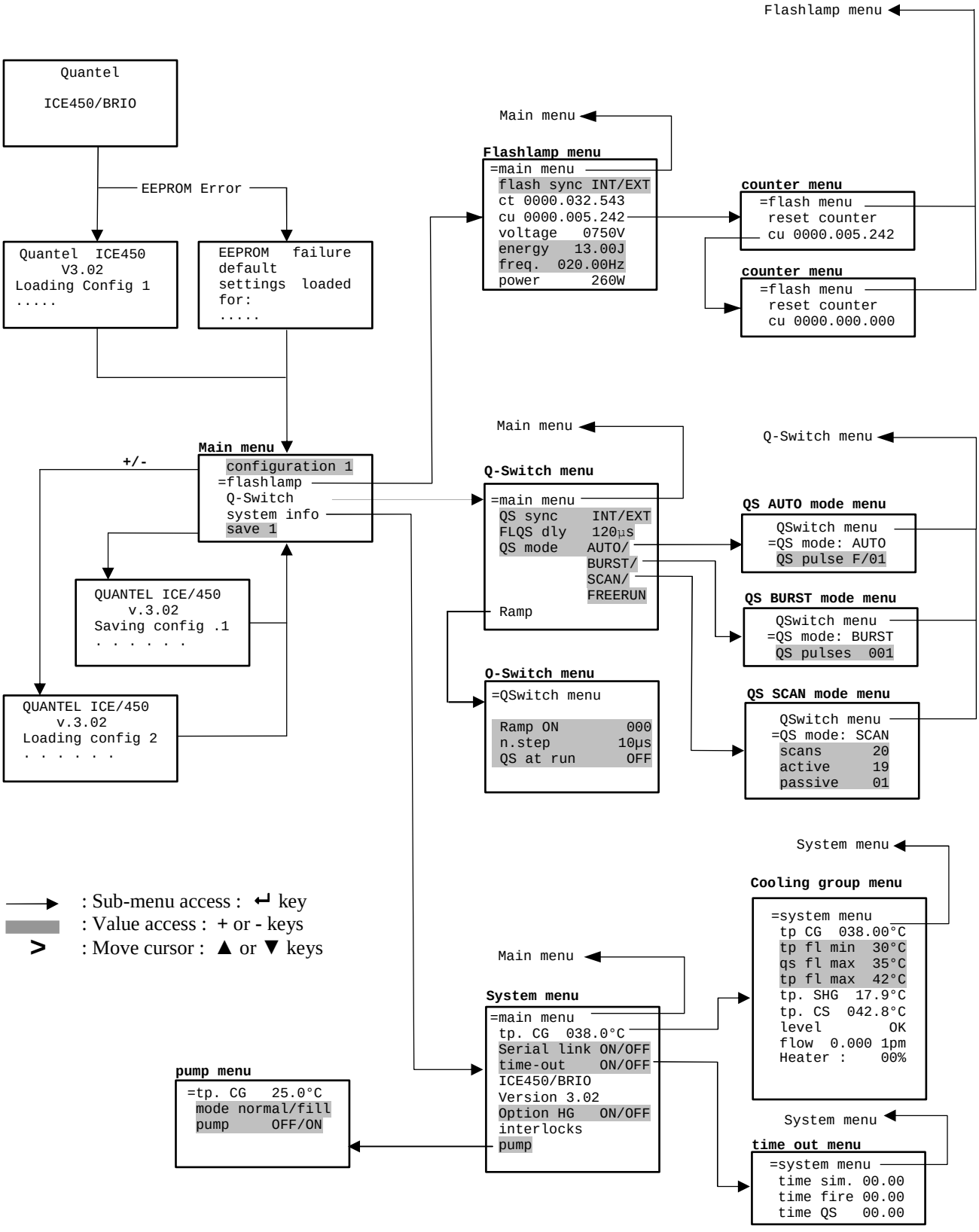


Figure III-6: schematic diagram of the menus available on the RB

III.3.e. UMBILICAL

This hose of about 3 m long connects the optical laser head to the power supply cabinet. It includes:

- High voltage cables to the flashlamp.
- Coolant hoses.
- Laser safety, power supply for HGM, synchronization lines.
- Earth conductor.

The way of connection of the umbilical is described in chapter II.3biii; to disconnect the system, please proceed as follows:

1. Shut down the ICE with the ON/OFF key (9 on Figure III-1).
2. Unplug the main cord from the mains at the back of the ICE.
3. Loosen the two screws of the power connector (1 of Figure III-7) on the ICE and laser head and disconnect them.

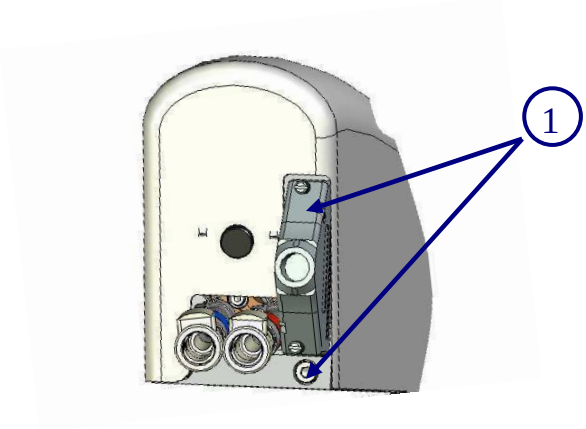


Figure III-7: Disconnection description

4. Unplug the two umbilical coolant tubes from the ICE (push on the female part to disconnect). Then depress the end of the

connectors so you drain the coolant in the tubes and in the laser head. (see Figure III-8). Do not fully cover the hole when depressing the end of the connectors, or the coolant will be prevented from flowing out.

Figure III-8: Coolant connector description

5. Carefully rotate the laser head to drain it totally. Note: the remaining quantity of coolant may be not negligible.

6. If you've already drained the ICE reservoir, the laser system is ready to travel, if not please follow the procedure described on chapter II.3.b.iv.

IV. SYSTEM OPERATION

While installing and using the laser in your experiments you should care about back reflections of the laser beam towards the laser itself. Back reflection from wattmeter, partially or totally reflected mirrors, metallic surfaces etc. can cause damage inside the optical cavity of the laser. The warranty will not apply in this case.

The flashlamp and Q-switch operation for the Brilliant EaZy are submitted to internal temperature control conditions and the user's may wait about 15 minutes after switching the cabinet key to the ON position before laser activation. The Brilliant EaZy is not submitted to these temperature control conditions and the user's should wait about 10 minutes each time he starts the flashlamp before starting the Q-Switch operation to be in the optimum conditions of the normal use of the laser.

IV.1. MODES OF OPERATION

Brilliant lasers provide three modes of operation (Manual, Automatic and External) for Nd:YAG rod pumping (flashlamp pulses) and three modes (Single shot, Automatic, External) for Q-Switching (laser emission).

The selection of the modes of operation is performed on the Remote control Box (see paragraph **III-3-b.ii**). For the flashlamp, through the use of buttons (**ready**, **start**) and screen display (**internal** or **external**). For the Q-Switch through the use, of buttons (**single shot, start**) and screen display (**internal** or **external**).

IV.1.a. MANUAL MODE

After switching on the key of the laser's power supply and when the laser is ready, press the ready button (RB) to initiate the Simmer

current in the flashlamp and the LASER ON indicator is lit up. When the Simmer indicator is lit up, a single flashlamp shot will be obtained by pressing the ready button.

This manual mode is primarily used to check the normal operation of the power supply and flashlamp. Laser emission should not be obtained under this mode, unless a special configuration has been implemented on the laser. Manual mode is described in figure **IV-1**

Please follow the standard safety precautions described in chapter I of this manual, even in this mode. During laser operation, all persons present in the laser room must wear safety goggles appropriate for the output wavelengths (see chapter I).

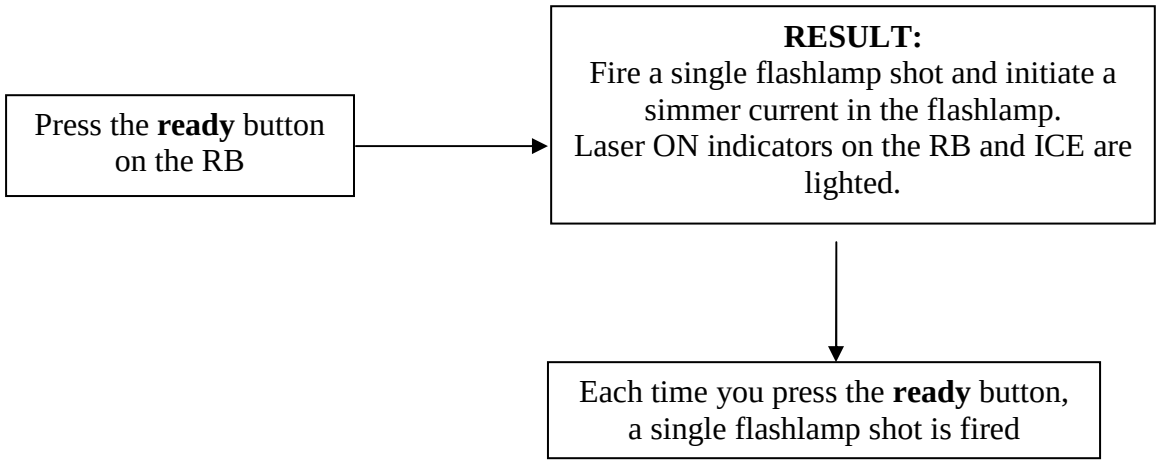


Figure IV-1: Manual mode

IV.1.b. AUTOMATIC MODE (INTERNAL & START)

In the internal (Int) synchronization mode, the "fire" command of the flashlamp is automatically generated by the controller board, at a rate determined by an internal clock. The Q-Switch is activated with a fixed delay (factory set or user delay set on the RB) after the beginning of the "fire" order. Automatic mode is described in figure **IV-2**.

This is the most common mode of operation at the factory set repetition rate for the Brilliant EaZy Nd:YAG laser. For 8s after flashlamp activation, the Q-Switch is inhibited to avoid transient thermal effects in the Nd:YAG rod.

For the resonator the internal repetition rate is factory set and can be changed only by QUANTEL personnel, or their representative.

For a stable resonator, the repetition rate can be changed through the remote box by the costumer. In this case, the specifications (energy, divergence, beam profile…) are only available at the factory repetition rate.

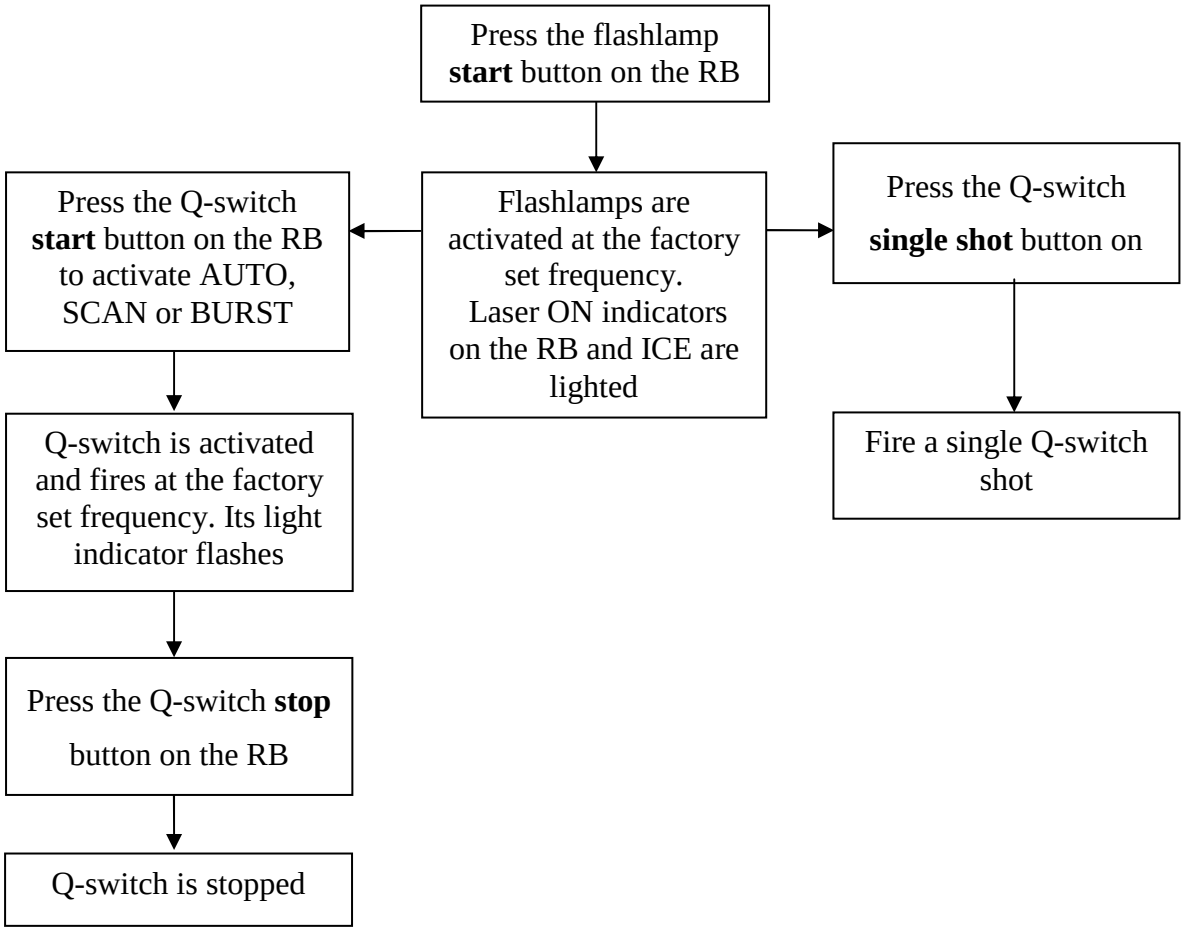


Figure IV-2: Automatic mode

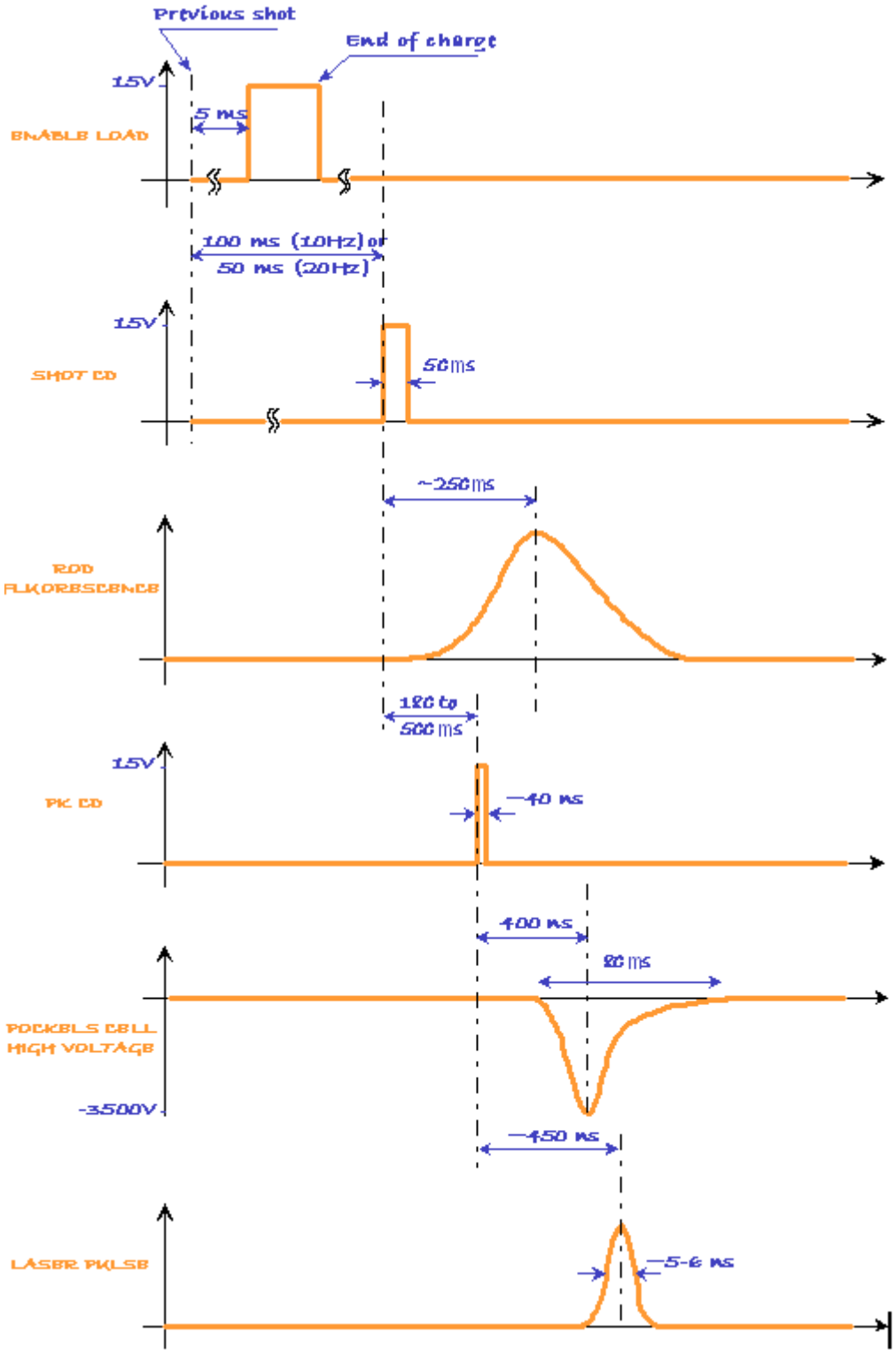
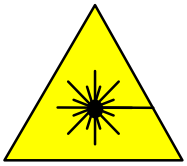


Figure IV-3: Automatic mode - timing diagram

IV.1.b.i. DECREASING THE OUTPUT ENERGY

Operation at a decreased energy level is beneficial when starting an experimental setup, testing equipment, etc. The RB provides easy access to this function, with the variable Flashlamp / Q-Switch delay: increasing the flashlamp / Q-Switch delay above the optimum value will result in a lower energy output pulse (as well as longer pulsewidth), thereby reducing the risk of damage to optics or detectors, while modifying slightly the laser's beam characteristics.



Decreasing the High Voltage of the flashlamp to reduce the output energy is less recommended: it will cause a change in beam characteristics (divergence, position of focal points) and in some instances may cause damage to the laser's internal optics.

To adjust the output energy, proceed as follows:

1. On the RB, select Q-Switch from the Main menu
2. Press Enter
3. Select Flashlamp / Q-Switch delay (FLQS dly) from the Q-Switch menu
4. Toggle the - and + buttons on the RB to adjust the output energy to the desired value
5. Press Enter

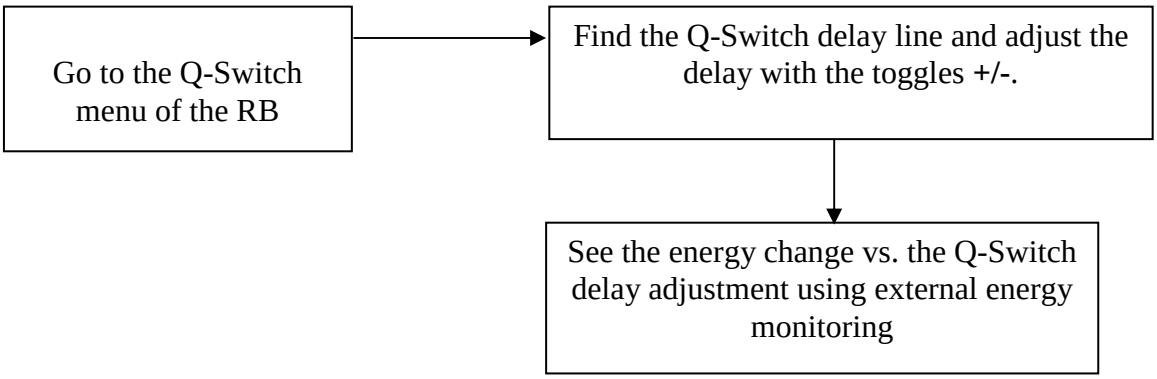


Figure IV-4: Decreasing the energy

IV.1.c. EXTERNAL MODES (EXT)

The laser is optimized in the QUANTEL factory at the repetition rate specified by the customer.
For a GRM laser in external mode, the repetition rate has to be equal to the initial setting (with an allowance of ± 5%). The laser performance is optimized for the factory-set repetition rate.

NOTE: Rising edges are active edges (for low jitter operation the rise time must be as short as possible: < 1µs).

To maintain a short risetime and minimal jitter, the input Q-Switch is not opto-coupled. Do not apply voltages greater than 5V.

For flashlamp and Q-Switch synchronization, the user must send signals as indicated in figure **III-2 & 3**. The delay between flashlamp and Q-switch synchronization signals may range from 135µs to 500µs. This delay must be measured and adjusted in order to optimize the laser operation (maximum energy).

The external mode can be used in different ways according to the synchronization specifications of the user's experimental set-up. These different ways are described below.

Flashlamp in external mode and Q-Switch in internal mode :

The electrical pulses in the flashlamp are synchronized to an external clock. The Q-Switch is internally triggered (factory set delay after the beginning of each electrical pulse or user delay set on the RB). In this mode, the accuracy of optical pulse synchronization with an external event is about 10µs. This mode is described in figure **IV-5**.

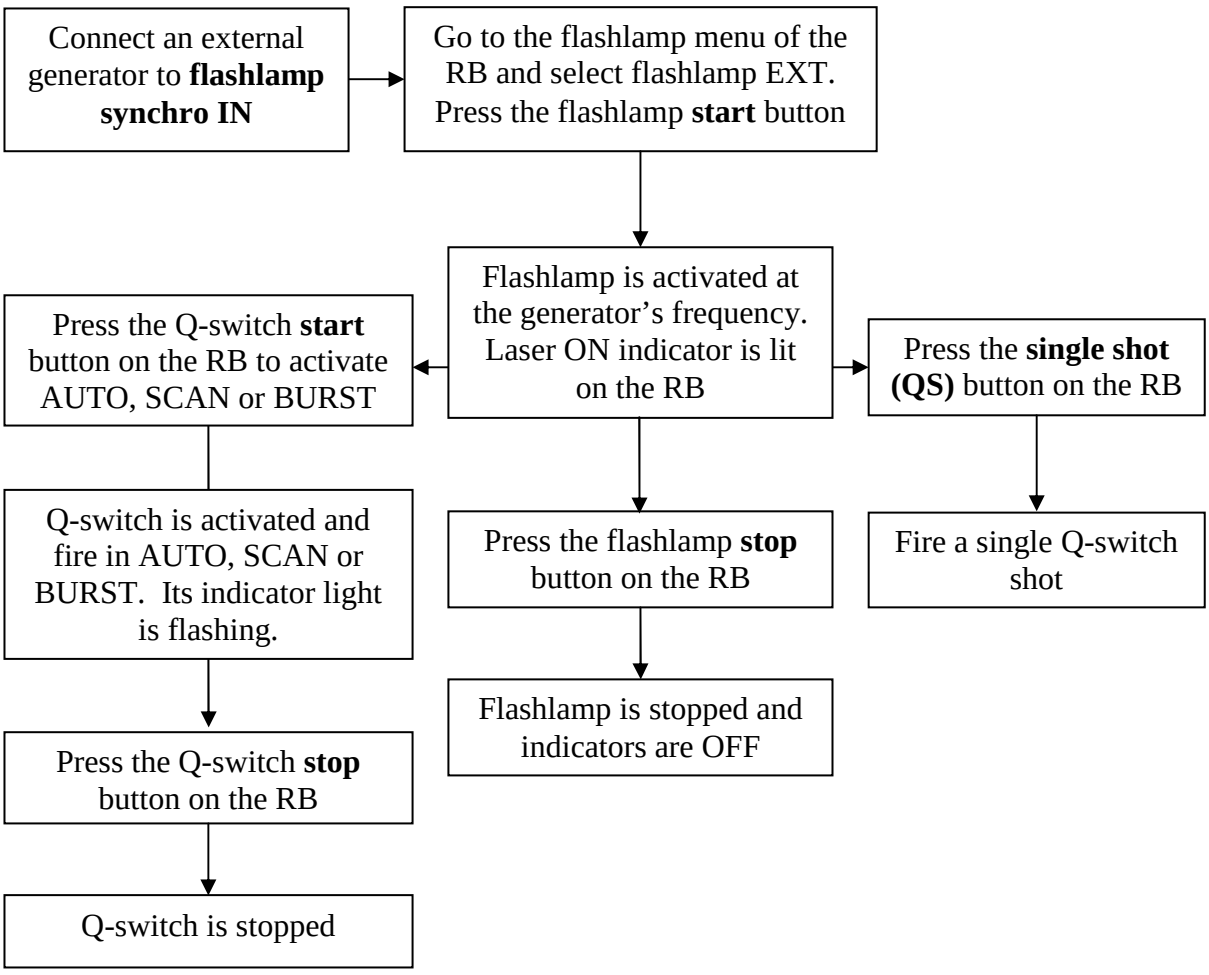
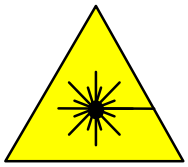


Figure IV-5: Flashlamp in external mode Q-Switch in internal mode

IV.1.c.i. FLASHLAMP IN INTERNAL MODE AND Q-SWITCH IN EXTERNAL MODE

In this mode of operation, the user must delay the flashlamp fire order (available on the flashlamp BNC SYNCHRO **OUT** with its own generator) and then connect the delayed signal to the Q-Switch BNC SYNCHRO **IN** connector. The time delay between the input signal and the Pockels trigger range from 600ns to 700ns from one laser to another, but is fixed for a given laser. In this case the jitter between the optical pulse and the fire order will be limited by the jitter of the delay generator, with a minimum value of ±0.5ns. The user must be aware that a delay different from the factory set value will induce a decrease of the output energy. To activate this choice you should press the start button on the RB as described in Figure **IV-6** or CC“CRLF” if you are using the serial port RS232.



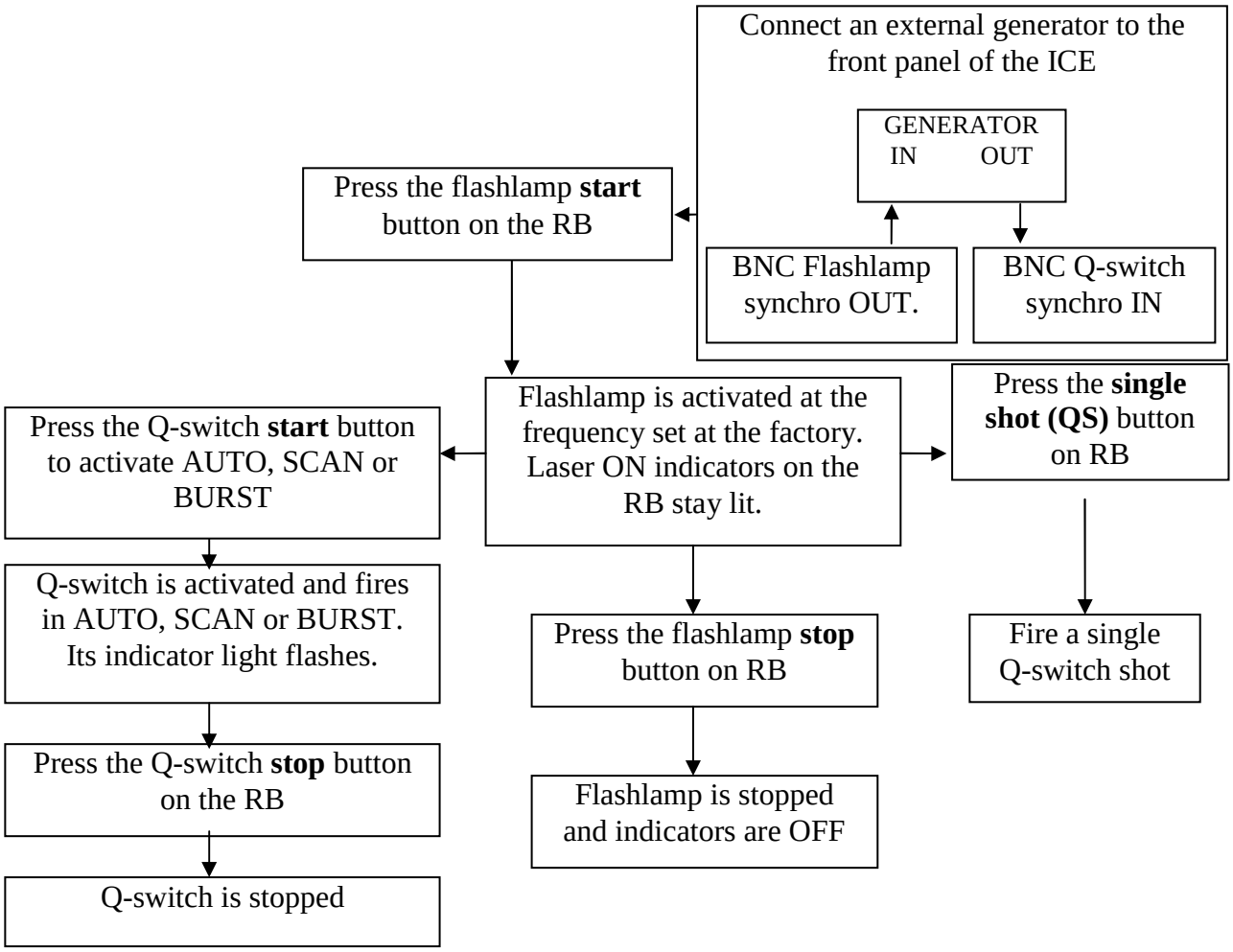


Figure IV-6: Flaslamp in internal mode and Q-Switch in external mode

IV.1.c.ii. FLASHLAMP AND Q-SWITCH IN EXTERNAL MODE

This mode is used when the laser emission has to be synchronized with the user's experimental set-up with an accuracy of a few nanoseconds to about 10µs (depending on the jitter of the delay generator).

As in the automatic mode of operation, the Q-Switch is inhibited for 8s after the activation of the flashlamp to avoid transient thermal effects in the Nd:YAG rod. This mode is described in figure **IV-7**.

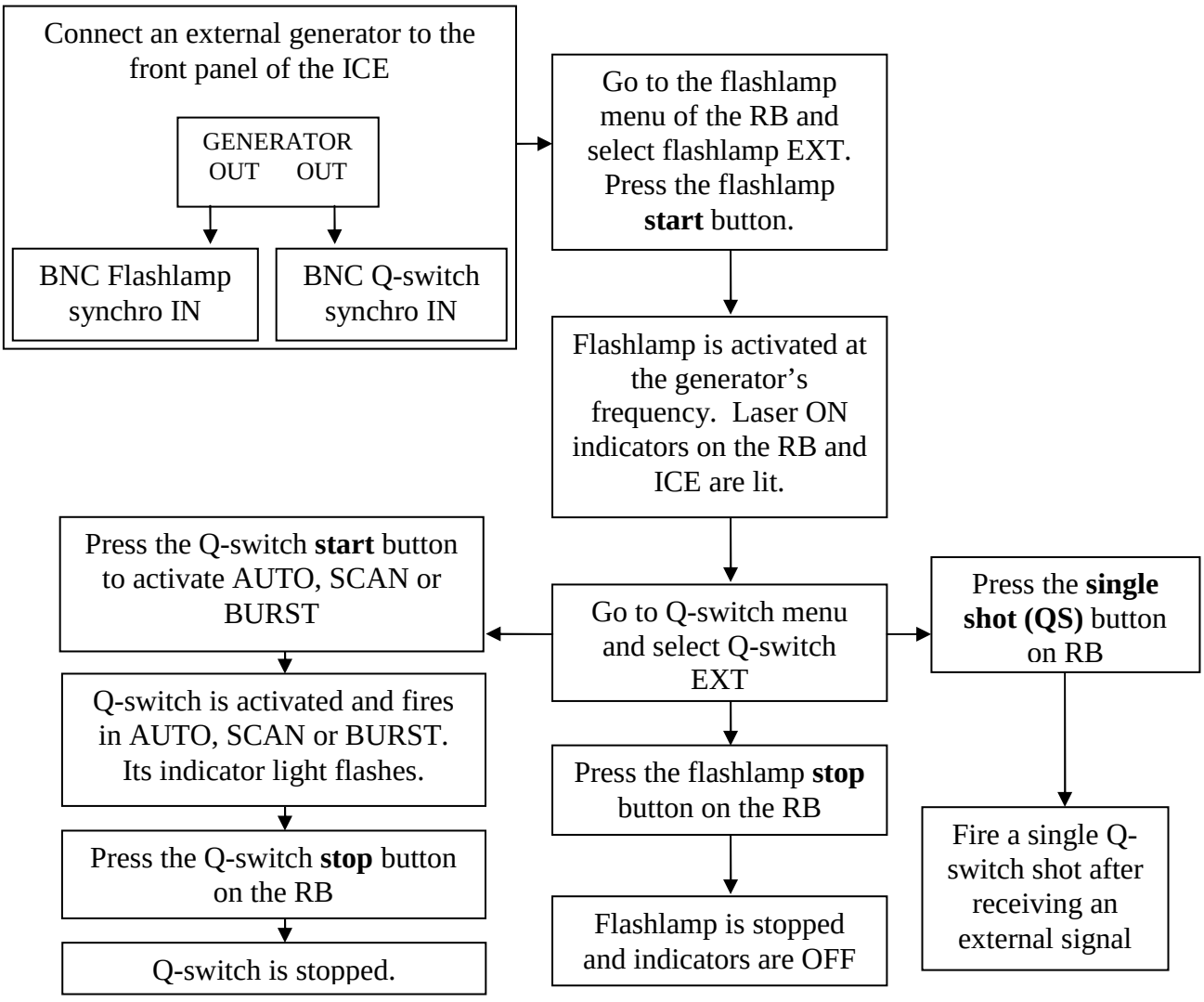


Figure IV-7: Flashlamp and Q-Switch in external mode

The time needed by the microprocessor to treat the external flashlamp signal is about 500µs. To optimize the energy, the external Q-Switch signal has to be delayed from the external flashlamps signal of 500µs.

IV.2. DAILY START-UP AND SHUTDOWN PROCEDURES

IV.2.a. DAILY START-UP PROCEDURE

To start the laser system up, please proceed as follows:

1. Turn the control key on the front panel of the ICE to the "I" (ON) position. The "**power**" and the "**interlock**" indicators on the RB must light up (if not, check for defaults on the RB screen - see chapter **VI**).

2. Wait 10-15 min until the water temperature reaches the preset value for flashlamp operation.

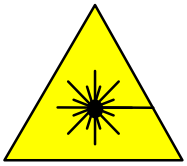
3. Press the **ready** button. Its LED indicator and the LASER ON indicators on the RB and on the front panel of the ICE must light up.

4. Select the configuration or the following. Select the operation mode: **internal** or **external** using display on RB.
   - in **external** mode, follow the procedures of section **IV. 1** to configure, connect the I/O cables to the laser inputs, and follow the procedure below.
   - in **internal** mode, follow the procedure below.

5. Press the **start** button of the flashlamp. Its indicator must illuminate, and the flashlamp fires at a fixed frequency. In external mode the flashlamp will flash when an external signal is supplied.

6. Open the laser's beam shutter. Its warning LED will illuminate.

7. Wait about 8 seconds before the Q-Switch control electronics enable normal operation of the laser. You may have to wait several minutes if the water temperature of the laser is below the preset value for Q-Switching operation.



The next step allows the laser to operate and a laser beam will be emitted from the output aperture.

1. Press the **start** button to activate the Q-Switch, and its light indicator flashes. In external mode the Q-Switch will fire when the external signal is supplied.

2. If HG crystals are used, a warm up time of 20 minutes from the switch on of the key is necessary before phase matching adjustment if needed.

3. To stop laser emission press the **stop** buttons on the Q-Switch and the flashlamp on the Remote box, their LED indicators should light off.

4. Rotate the manual shutter to the closed position.

IV.2.b. DAILY SHUTDOWN PROCEDURE

To stop the laser emission press the **stop** buttons of the Q-Switch and flashlamp on the RB, their LED indicators must switch off.

Close the beam shutter of the laser, its warning LED goes out.

Turn the control key on the front panel of the PCC to the "O" position.

IV.3. NORMAL OPERATION

IV.3.a. GENERAL SET-UP AND FUNCTIONS

Do not attempt to modify the pumping power by increasing the charging voltage on the remote control box of the ICE. This voltage has been factory set for optimisation of the laser performances.

In case of flashlamp efficiency decrease, this voltage may need to be adjusted. Contact QUANTEL's Service Department to confirm the default.

After the start-up procedure (see Paragraph **IV.2**) has been completed, the output of the laser is controlled only via the remote control box (RC).

1. Continuous emission at the factory-set up rate

   - Continuous emission of the laser pulses is obtained when the Q-Switch "start" button is pushed; its light indicator and the warning LED of the beam shutter of the laser flashes.

   - To disable the laser emission, push the "**stop"** button of the Q-Switch; then its light indicator and the warning LED of the beam shutter of the laser stop flashing.

2. Single pulse emission

   - Single pulse emission from the laser is obtained when "**single shot"** button is pushed; and its light indicator flashes one time.

   - This mode is mainly used to perform alignments of the user's experimental set-up.

IV.3.b. HARMONIC GENERATION

IV.3.b.i. FIRST EXPLICATION

Depending on the laser configuration, the emitted wavelength can be 1064nm, 532nm, 355nm, 266nm or 213nm with some combinations as detailed in Paragraph **III.2.c**. The different fundamental and harmonic beams are separated inside the Harmonic Generation Module (HGM) as described in Paragraph **III.2.b**.

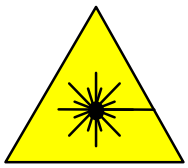
The warm-up time of the harmonic generator crystals is about 20 minutes after turning "I" the key on the front panel of the PCC. The optimisation of the harmonic energy is made through the use of the phase-matching adjustment screw (see Figure **III-2**, the screwdriver is delivered with the laser). Half a turn in either direction should be enough to reach phase-matching.

For Fourth Harmonic Generation FoHG, the non-linear crystal is temperature phase-matched. The tuning temperature is adjusted by the potentiometer. A low value of the potentiometer corresponds to a high temperature of the crystal cell (the temperature range is from 35 to 65 °C). The phase-matching value is indicated on the Quality Control data sheet of the laser or FoHG module.

Before operating the laser with 3ω or 4ω, you have to select the right HGM option on the Remote control Box. To select your option choose the "system info" submenu and get to the options 3ω or 4ω, and toggle buttons (+) and (-). For a 4ω, the “option HG” value should be set at 1. For all the other wavelengths, it should be set at 0.

Angle (2ω, 3ω, 5ω) or temperature (4ω) tunings must be performed while monitoring the output energy in the desired wavelength (calorimeter type detector).

In general case, the wave plate in the SHG (see paragraph **III.2.b**) is oriented to obtain the maximum output energy at the wavelength of major use of the user. If the user is interested to obtain the maximum energy that the laser can deliver at the other wavelength, he has to optimize the wave plate orientation. After assembling the last HG, let's consider the THG for example, wait about 20 minutes and optimize the phase-matching adjustment screws.



During these operations, all people present in the laser area must keep the laser protective eyewear on (see Chap. I).

Then proceed as follows without stopping the laser:

1. Unscrew the four screws of the SHG module protective housing and pull it off.

2. Unscrew the three screws of the plate on the SHG module side.

3. Unscrew the screw which tights the wave plate position and put the smallest Allen key (n° 15) delivered with the laser into a hole of the wave plate mount.

4. When looking at the output energy at 355 nm, adjust very finely the orientation angle of the wave plate to the maximum energy at 355 nm.

5. Keep the orientation of the wave plate when tightening the screw.

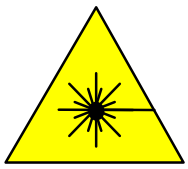
6. Optimize a second time the phase-matching adjustment screws of SHG and THG (while monitoring the 355 nm energy).

7. Put back the plate and the protective housing by reversing steps **2.** and **1.**.

When the user comes back to SHG, FoHG or FiHG, this operation has to be repeated with the SHG only.

IV.3.b.ii. OPERATING PROCEDURE OF FOURTH HARMONIC GENERATOR (4TH HG)

This paragraph is dedicated to the installation and daily operation procedures of the Fourth Harmonic Generation Module (4th HGM). This document is valid for **Brilliant** with software issue 1.2 and higher or **BriliantB**. For a successful operation please proceed as follows, (if the 4th HGM is delivered with the laser, the user is invited to skip to daily operation) :



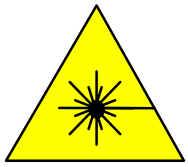
1. Before installing the 4th HGM, the user has to shut down the laser by following the procedure described in paragraph **IV.2.b** of the **Brilliant**'s Instruction Manual.

2. Paragraph **III.2.b&c** of Brilliant's instruction manual is dedicated to detailed description of these modules.

3. Be sure that the beam dump is attached to the front face of 4th HGM.

IV.3.b.ii.a. STARTUP PROCEDURE

In this procedure the user will find the operating value of the potentiometer, which depends on the characteristics of the second harmonic beam. Please proceed as follows:



1. The user is requested to put on the laser protective eyewear at 1064nm, 532nm, and 266nm before operating the laser.

2. Set the potentiometer located on the top of the 4th HGM at 999 value.

3. Turn on the laser during 15 minutes with flashlamp ON.

4. Put a white paper in front of the output port of the 4th H beam.

5. Activate the Q-Switch during at least 7 minutes

6. Adjust finely the phase matching adjustement knob of the SHG to obtain the brighter and more uniform spot on the white paper. You can use a whattmeter but you should take off the 4th HGM, and put on the dichroic mirrors at 532 nm in the SHG.

7. Stop the Q-Switch operation, and replace the white paper with an energy meter in front of the output port of the 4th HGM.

8. Set the potentiometer located on the top of the 4th HGM at 150 value and wait about 10 minutes.

9. Activate the Q-Switch during at least 7 minutes

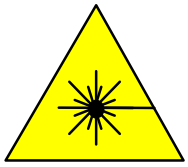
10. Note the output energy as a function of the of the potentiometer reading by increasing from 150 with 100 graduations step until passing beyond the maximum output energy (which is higher than the specification, let (R1) be this value. For each step you have to wait until the stabilisation of the output energy (some minutes).

11. Set again the potentiometer at (R1-100) value and wait about 10 minutes. Note the output energy as a function of the potentiometer reading by increasing from (R1-100) with 10 graduations step until passing beyond the maximum output energy, let (R2) be this value. For each step you have to wait until the stabilisation of the output energy (some minutes).

12. Using your notes, let (R3) be the potentiometer value corresponding to the laser specification. For a good stability of the 4th HGM output energy, the operating value is Roper = (R3).

IV.3.b.ii.b. DAILY OPERATION

This operating value of the potentiometer Roper (see the QUALITY CONTROL, Final Test Data Sheet), is known. Please proceed as follows:



1. Set the Roper value on the potentiometer.

2. The user is requested to put on the laser protective eyewear at 1064nm, 532nm, and 266nm before operating the laser

3. Turn on the laser during 15 minutes

4. Turn on the flashlamp and turn on the Q-Switch during at least 7 minutes.

5. Check the 266nm output energy. If it is lower than the 4th HG specification please continue this procedure.

6. Stop the Q-Switch (remote control).

7. Set the potentiometer located on the top of the 4th HGM at 999 value.

8. Put a white paper in front of the output port of the 4th H beam.

9. Activate the Q-Switch during at least 7 minutes

10. Adjust finely the phase matching adjustement knob of the SHG to obtain the brighter and more uniform spot on the white paper.

11. Stop the Q-Switch operation, and replace the white paper with an energy meter in front of the output port of the 4th HGM.

12. Set the potentiometer located on the top of the 4th HGM at Roper value and wait about 10 minutes.

13. Acivate the Q-Switch during at least 7 minutes

Three situations could be observed:

- The output energy is equal or higher than the 4th HGM energy specification.

- The output energy did not reach the specification. Increase the potentiometer value with 5 graduations step, and check the output energy. For each step you have to wait until the stabilisation of the output energy (some minutes).

- The output energy has passed beyond the maximum energy and decays below the 4th HGM energy specification.

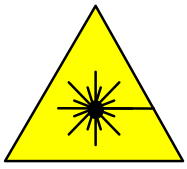
- Stop QS, decrease the potentiometer value with 20 graduations step, and wait about 5 minutes.

- Activate the QS and check the output energy. For each step you have to wait until the stabilisation of the output energy (some minutes).

Note that each times the Q-switch is stopped, after activating the Q-Switch and in order to reach the full energy, the user has to wait about five minutes.

IV.3.b.iii. OPERATING PROCEDURE OF FIFTH HARMONIC GENERATOR (5TH HG)

This paragraph is dedicated to the installation and daily operation procedures of the Fifth Harmonic Generation Module (5th HGM). This document is valid for **Brilliant** with software issue 1.2 and higher or **BriliantB**. For a successful operation please proceed as follows, (if the 5th HGM is delivered with the laser, the user is invited to skip to daily operation) :



1. Before installing the 5th HGM, the user has to shut down the laser by following the procedure described in Paragraph **IV.2.b** of the Brilliant's Instruction Manual.

2. Paragraph **III.2.b&c** of Brilliant's instruction manual is dedicated to detailed description of these modules.

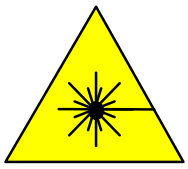
3. Be sure that the beam dump is attached to the front face of 5th HGM.

4. The laser configuration in Fifth Harmonic generation is:

IR source | 2w | 4w | 5w + dichroïcs mirrors and beam dump

IV.3.b.iii.a. STARTUP PROCEDURE

In this procedure the user will find the operating value of the potentiometer of the 4th HGM for the use of 5th HGM. Caution, this value is specific to the use of 5th HGM. Before applying this procedure, the SHG (2w) module must be phase matched at maximum energy (see 4th HGM operating procedure). Please proceed as follows :



1. The user is requested to put on the laser protective eyewear at 1064nm, 532nm, 266nm, and 213nm before operating the laser.

2. Set the potentiometer located on the top of the 4th HGM at 100

3. Turn on the laser during 15 minutes

4. Turn on the flashlamp and turn on the Q-Switch during at least 7 minutes

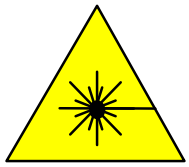
5. Note the output energy of the 5th HGM as a function of the of the potentiometer reading by increasing from 150 with 100 graduations step. For each step you have to wait until the stabilisation of the output energy (some minutes), and after that to phase match the 5th HGM. Continue the increasing steps until passing beyond the maximum output energy (which is higher than the specification, let (R1) be this value.

6. Set again the potentiometer at (R1-100) value and wait about 10 minutes. Note (as point 5) above) the output energy as a function of the potentiometer reading by increasing from (R1-100) with 10 graduations step until passing beyond the maximum output energy, let (R2) be this value.

7. Using your notes, let (R3) be the potentiometer value corresponding to the laser specification at 213nm. For a good stability of the 5th HGM output energy, the operating value is Roper = (R3). Please write this value in the following paragraph.

IV.3.b.iii.b. DAILY OPERATION

The operating value of the potentiometer (see the Roper on the QUALITY CONTROL, Final Test Data Sheet), is known. Please proceed as follows:



1. Set potentiometer value on 5wRoper.

2. The user is requested to put on the laser protective eyewear at 1064nm, 532nm, 266nm and 213nm before operating the laser

3. Turn on the laser during 15 minutes

4. Turn on the flashlamp and turn on the Q-Switch during at least 7 minutes.

5. Check the 213nm output energy. Adjust finely the phase matching of the 5w module (do not change 2w module phase matching), if it is lower than the 5th HG specification please continue this procedure.

Two situations could be observed:

- The output energy did not reach the specification. Increase the potentiometer value with 5 graduations step, and check the output energy. For each step you have to wait until the stabilisation of the output energy (some minutes), and after that to phase match the 5th HGM.

- The output energy has passed beyond the maximum energy and decays below the 5th HGM energy specification.

- Stop QS, decrease the potentiometer value with 20 graduations step, and wait about 5 minutes.

- Activate the QS and check the output energy. For each step you have to wait until the stabilisation of the output energy (some minutes).

Note that each times the Q-switch is stopped, after activating the Q-Switch and in order to reach the full energy, the user has to wait about five minutes.

V. MAINTENANCE

The laser requires minimal maintenance if it is operated in a standard laboratory environment with specified power line and ambient temperature (see Paragraph II).

The closed laser structure provides dust-free operation for optical components, and the laser should never be operated without the protective housing. If a malfunction occurs, the troubleshooting procedures described in Paragraph VI of this manual, must be followed as a first step. If the problem remains, call QUANTEL service department (or its representative) to make a first diagnosis.

Except in specific cases, servicing requires the laser return with its original shipping container to a QUANTEL service facility. The other maintenance operations, easy to achieve by the user, are alignment verification, flashlamp replacement and Cooling Group Unit (CGU) maintenance. In the optical head, the only consumable are the flashlamp, whose efficiency decreases with the number of accumulated shots and which must be replaced when the following message “Please change lamp and maintain CGU” is displayed on the screen of the remote control box, or when the output energy has fallen under a limit unacceptable for the experiment. The flashlamp have to be replaced every 6 to 12 months, depending upon the laser repetition rate. In the PCC, the CGU water has to be changed every 30000 fires and deionization cartridge have to be changed every 6 months.

V.1. GENERAL MAINTENANCE PROCEDURES

- The laser needs minimal maintenance if it is operated in a normal laboratory environment with specified power line and cooling water characteristics (see Paragraph II).

- The electronic units do not require maintenance.

- In the optical head, the flashlamp efficiency decreases with the number of accumulated shots. The flashlamps must be replaced when the output energy has fallen under a limit acceptable for the experiment. The flashlamp replacement procedure is described in the Paragraph V.2.

- The replacement frequency for flashlamp, recommended by Quantel to ensure correct laser operation, is every 30 Million shots (average lifetime) or once a year.

- If some optical damage occurs on the laser components, QUANTEL's service department (or its representative) must be contacted to make a diagnosis of the problem. In most of cases, replacement of an optical component requires a specific know-how of the system; it is then necessary to have it performed by a QUANTEL service engineer or its representative.

- In order to minimize the risk of damage created by the presence of dust on the optical components, the laser should never be operated without a cover.

V.1.a. THE OPTICAL HEAD

Burn patterns are used to obtain information about the laser alignment in a simple way. To check the burn patterns proceed as follows:

Follow the start-up procedure (see Paragraph IV.2.a).

1. Use the "**single shot"** button of the RB, to operate the laser. **Note:** to obtain a perfect view of the spot, and before make a single shot with the RB, push the "**start**" button of the RB and

lets the system shooting during 20 seconds, then stop it and push the "**single shot**" button of the RB.

2. Set a piece of burn paper (delivered with the laser) at 30 cm from the output port and fire a single pulse on the white side of the burn paper.

3. Compare the burn patterns to the one delivered with the laser. If there is no significant difference observed, the laser is still aligned. If not, call QUANTEL service department.

V.1.b. FLASHLAMPS REPLACEMENT

The efficiency of the flashlamp decreases with the number of accumulated shots. The flashlamps must be replaced when the following message "Please change lamp and maintain CGU" is displayed on the screen of the remote control box, or when the output energy has fallen under a limit unacceptable for the experiment.

The flashlamp delivered by QUANTEL are qualified by the Quality Control Department. They are individually qualified to be in accordance with QUANTEL's equipment. Samples from different suppliers are regularly tested by our Quality Control Department for lifetime (laser output energy measurement versus time). These tests allow providing users with flashlamp which are mechanically, electrically and optically well adapted to Brilliant EaZy. The following references should be indicated to Quantel service department when you order flaslamp:

- Brilliant EaZy: SFLBR1-06.

Flashlamps are fragile and must be handled with care. Breaking a lamp can be dangerous. New lamps should be handled with clean optical gloves to avoid oil, moisture or dust deposition.

Flashlamp replacement does not require any tool. To replace the flashlamp, please proceed as follows:

1. Follow the procedure of the Paragraph VI.2.b to shut down completely the electronics and the cooling group.

2. Unplug the main cord from the mains.

3. Remove the screw on the back side of the protective housing. Slide the protective housing toward the rear side of the laser by about 20 mm, and pull it off. The Draws V.1 and V.2 shows a top view of the pump cavity cover.

4. Gently unplug the flashlamp end wires (**A**).

5. Unscrew the two watertight nuts (**B**).

6. Remove the five screws (**C**).

7. Turn the lever (**D**) in the clockwise direction until the cover loosens, and turn it back.

8. Gently pull the pump cavity cover. The Draws V.3 and V.4 shows a side view of the pump cavity cover.

9. Unscrew the two flashlamp securing screws (**E**).

10. Gently take the flashlamp out of its bed (**F**), and pull its end wires through the watertight pieces (**G**).

11. Put the used flashlamp away and take the new one out of its package.

12. Identify the anode (+) and cathode (-) positions of the new flashlamp (see Picture V.1) to be mounted, and gently push its end wires through the watertight pieces (**G**) with respect to the polarity indicated on the pump cavity cover.

13. Gently place the flashlamp in its bed (**F**).

14. Slightly tighten the two flashlamp securing screws (**E**). A simple contact is required to get an efficient securing of the flashlamp. Do not make any additional effort after reaching the contact.

15. Tighten the two watertight nuts (**B**). The part of the wires between the flashlamp and the nuts must not be strained.

16. Be sure that the flat red joint is in place, and put back in place the pump cavity cover.

17. The lever (**D**) has to be in the position indicated in the Draws V.1 and V.2.

18. Tighten the five screws (**C**) uniformly until the cover is in contact with pump cavity.

19. Gently put back the ferrites (2 per wire) and plug the flashlamp end wires (**A**).

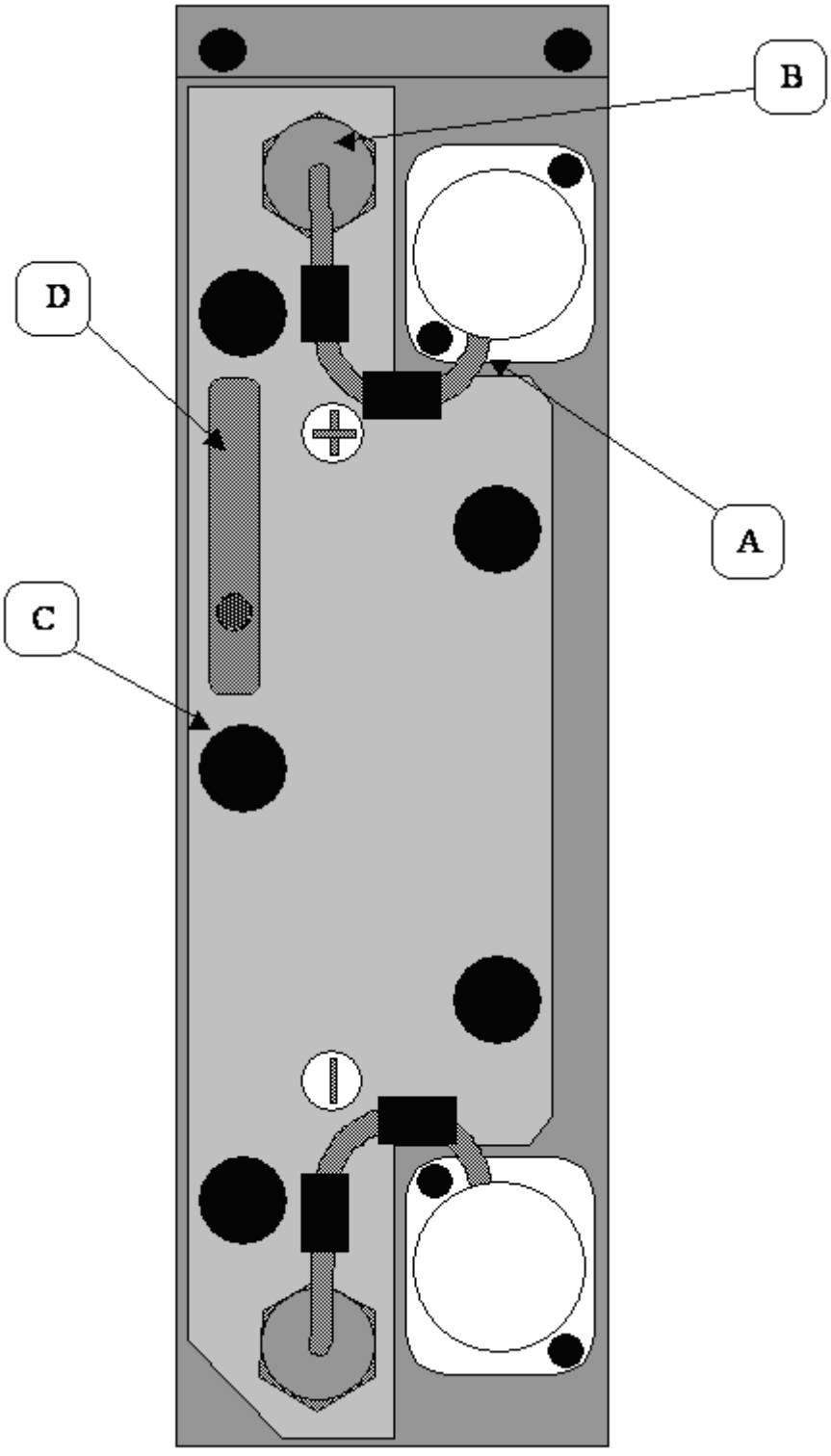
20. Plug the main cord on the main supply.

21. Turn on the key on the front panel of the ICE, and observe if there is any leak of water from the pump cavity cover side. If

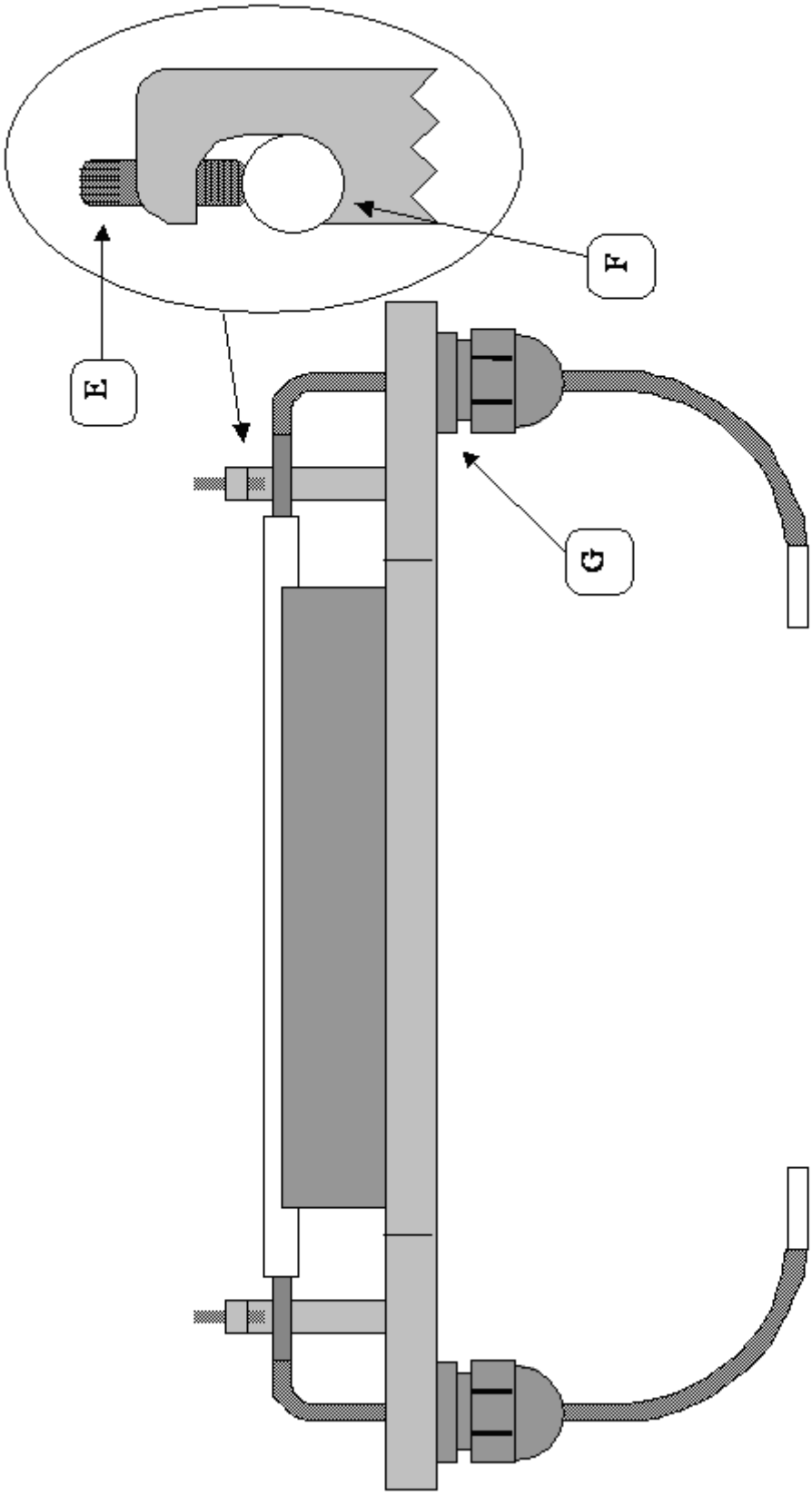
this happens, the five screws (**C**) have to be tightened further or the flat red joint is not in the correct place.

22. Put the protective housing back and push it, holding it by the part that should go inside the groove at the front end of the laser. Tighten the screw on the back side of the protective housing.

23. Use the remote control box to reset the flashlamp user's counter (see *Paragraph III.3.c*). The following submenu will lead you to perform this task: Main menu, flashlamp submenu, cu submenu, reset counter submenu, put the arrow in front and validate. The displayed counter should be cu 000.000.000.



Draw V-1



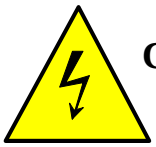
Draw V-2

V.2. THE COOLING GROUP

The ICE450 systems can provide years of reliable performance given proper handling and some simple routine maintenance. Visually inspect your ICE450 monthly for coolant leaks, abnormal noises, and damage to connectors and coolant ports. If you are a sporadic user where the system may sit unused for weeks at a time it is recommended that you power-up the ICE450 once a week for an hour to circulate the coolant throughout the system. This will prevent bacterial growth in the coolant system and maintain ideal coolant properties for trouble-free laser operation.

If the system is to remain unused or stored for extended periods of time (> 6 months) then it is highly recommended that you completely drain the cooling group from the system as described in Chapter II.

Demineralised water so as de-ionization cartridge must be replaced every six months just as you would regularly change the oil filter in your car. Please follow this procedure to change the de-ionizing cartridge :

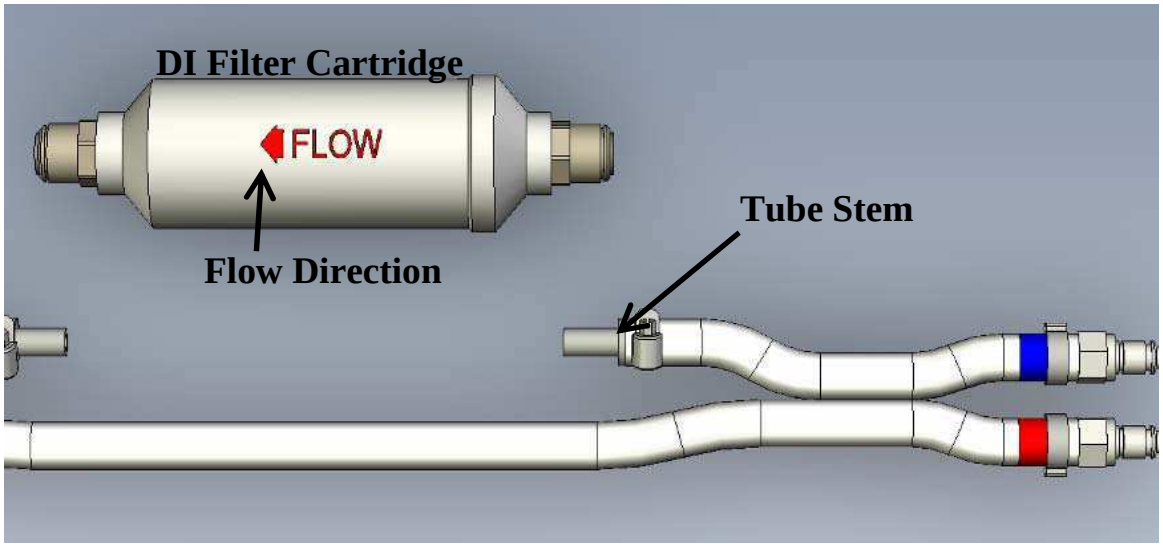


CAUTION: Before proceeding, switch the ICE450 OFF using the "Power Key Switch" (Item 10 of Figure III-1) and unplug the AC power cord.

1. Disconnect the Coolant Lines from the back of the ICE450 Power Supply and the Laser Head and drain the coolant from the Blue Line.

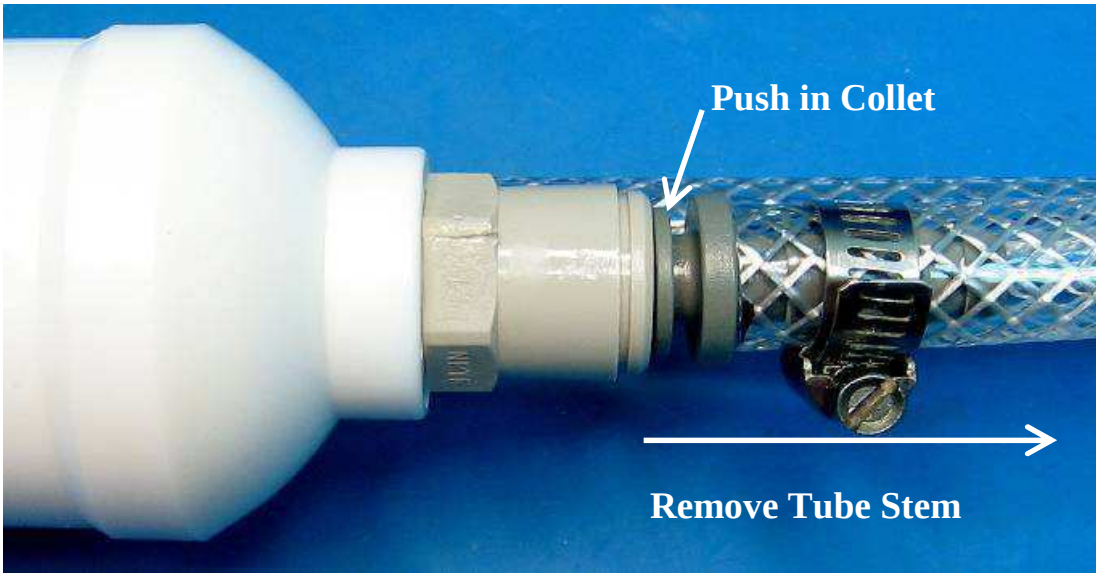
Coolant Lines at the back of the Power Supply

2. Locate the DI Filter Cartridge and note the Flow Arrow direction before removing it.



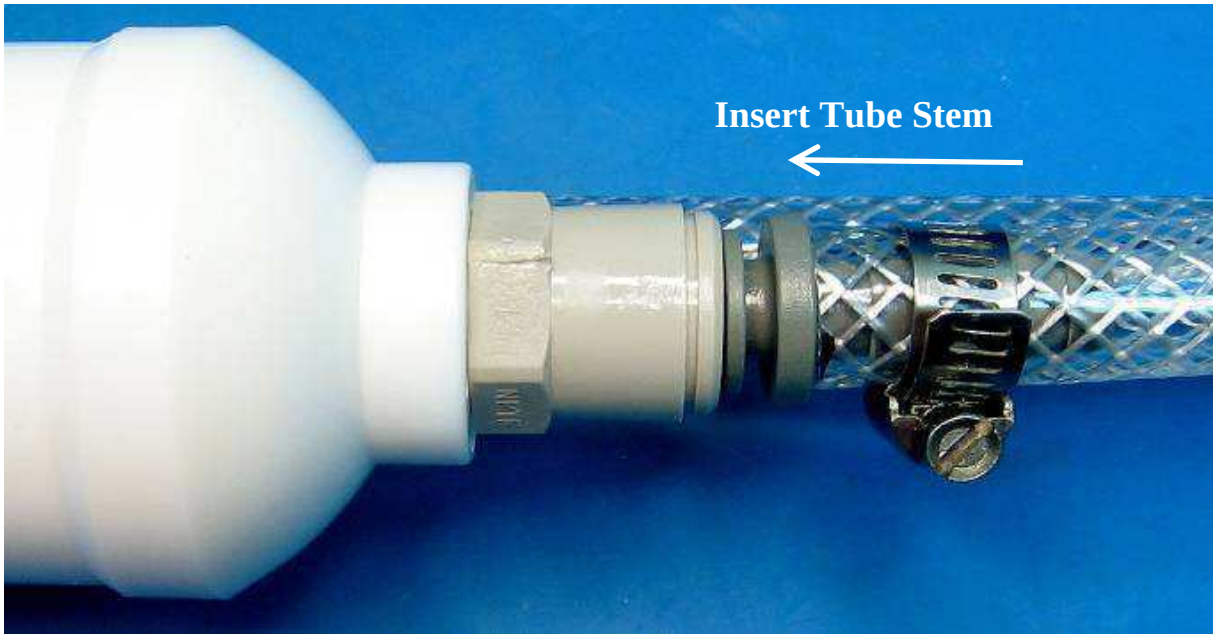
Note Flow direction

3. Push in the Collet against the face of the Cartridge Fitting. With the Collet held in this position the Tube Stem can be removed.



Disconnecting the Fittings

4. Orient the new Cartridge Flow Arrow in the correct direction (away from the Power Supply). Then push the Tube Stems into the Cartridge Fittings, one at a time to the internal Stop.



Connecting the Fittings

5. Try to pull the Coolant Lines out of the Cartridge to verify secure connection.

Checking Security

6. Reconnect the Coolant Lines to the back of the ICE450 Power Supply and Laser Head, then refill any lost coolant

Ethylene-glycol purge procedure :

If you need to ship the laser for any reason during winter time, we strongly recommend you to follow Ethylene-glycol purge procedure. Please proceed as follows :

1. Prepare a mixture: 50% of Ethylene glycol (BDH Prolabo Analar Normapur) and 50% of deionised water.

2. Drain water system completely (see V-3-a)

3. Refill to ¾ of maximum with mixture, circulate for 3 min.

4. Drain, the mixture from the system.

VI. TROUBLESHOOTING

VI.1. INTRODUCTION

Troubleshooting of the laser falls into two distinct categories: optics and electronics.

The electronics troubleshooting can be done by the user when the problem is created by a security system (external safety interlock, beam security, HV head security) or a connection deficiency. The following advices will help the user to fix the problem or to make a first step in the diagnosis before calling QUANTEL service department.

The problems of output energy decay can easily be fixed by the user if they are related to harmonic generation crystals phase matching tuning or flashlamp efficiency. If an optical component is damaged, its replacement and realignment requires repairing by QUANTEL's service department.
In any failure cases (at startup or during operation), the best way to detect the failure is to shut the laser off (see section IV.2 b) and to follow the troubleshooting diagnostics indicated in the following paragraphs.

- of the ICE.
- The main AC power source.
- The manual capacitor switch has to be in the pulled position.
- The main fuse on the rear panel of ICE.

VI.1.a. OPTICAL TROUBLESHOOTING

The **Brilliant Eazy** resonator is aligned at QUANTEL plant and does not requires any realignment operation. In this section we consider the energy troubleshooting which can be adjusted by the user, while for beam quality degradation, the user is invited to call QUANTEL service department or its representative.

VI.1.a.i. 1064NM OUTPUT ENERGY DECREASE

- Check the voltage applied to the flashlamp. That can be checked by using the menu displayed on the screen of the RB as specified in Paragraph III.3.d.iv

- Increase the flashlamp voltage as specified in Paragraph III.3.d.ii.

- Replace the flashlamp by following the procedure described in Paragraph V.1.b.

- Check the Q-Switch repetition rate in “auto, burst or scan” mode (see Paragraph III.3.d.iii and figure III-5b) and readjust it if necessary.

- Check the Q-Switch time delay (control with a power meter) and optimize it by using the RB (see Paragraph III.3.d.iv and figure III-6).

VI.1.a.ii. 532NM (SHG) OUTPUT ENERGY DECREASE

- After a warm-up time of 20 minutes, adjust the angle tuned phase matching of the SHG as well as obtaining the maximum output energy. Wait few minutes and recheck the output energy and if necessary readjust finely the SHG phase matching.

- Check the 1064nm (IR) output energy by disassembling the SHG module as describe in Paragraph III.2.c.iv.

- Check for SHG crystal and dichroic mirror damage.

VI.1.a.iii. 355NM (THG) OUTPUT ENERGY DECREASE

- Check on the RB “System info” menu, the HG option enable is 3W (see Paragraph III.3.d.iv and figure III.6).

- After a warm-up time of 20 minutes, adjust the angle tuned phase matching of the THG as well as obtaining the maximum output energy. Wait few minutes and recheck the output energy and if necessary readjust **finely** the SHG then the THG phase matching (one after the other).

- Check the 532nm (SHG) output energy by disassembling the THG module as describe in Paragraph III.2.c.iii.

- Check the 1064nm (IR) output energy by disassembling the SHG module as describe in Paragraph III.2.c.iv.

- Check if the THG Dichroic mirror is the good one installed in the THG (it may be exchanged with the SHG dichroic mirror).

- Check for SHG and THG crystals damage and dichroic mirror damage too.

VI.1.a.iv. 266NM (FOHG) OUTPUT ENERGY DECREASE

- Check on the RB “System info” menu, the HG option enable is 4W (see Paragraph III.3.d.iv and figure III.6).

- After a warm-up time of 20 minutes, adjust the angle tuned phase matching of the FoHG as well as obtaining the maximum output energy.

- Adjust **finely** the SHG phase matching angle to improve the FoHG output energy.

- Check the 532nm (SHG) output energy by disassembling the THG module as describe in Paragraph III.2.c.iii.

- Check the 1064nm (IR) output energy by disassembling the SHG module as describe in Paragraph III.2.c.iv.

- Check if the FoHG Dichroic mirror is the good one installed in the FoHG (it may be exchanged with another HG dichroic mirror).

- Check for SHG and FoHG crystals damage and dichroic mirror damage too.

VI.1.a.v. 213NM (FIHG) OUTPUT ENERGY DECREASE

- Check on the RB “System info” menu, the HG option enable is 4W (see Paragraph III.3.d.iv and figure III.6)

- After a warm-up time of 20 minutes, adjust the angle tuned phase matching of the FiHG as well as obtaining the maximum output energy.

- Adjust finely the FoHG temperature phase matching, to improve the FoHG output energy.

- Adjust finely the SHG phase matching angle to improve the FoHG output energy.

- Check the 532nm (SHG) output energy by disassembling the FoHG and FiHG modules as describe in Paragraph III.2.c.iii.

- Check the 1064nm (IR) output energy by disassembling the SHG module as describe in Paragraph III.2.c.iv.

- Check if the FiHG Dichroic mirror is the good one installed in the FiHG (it may be exchanged with another HG dichroic mirror).

- Check for SHG, FoHG and FiHG crystals damage and dichroic mirror damage too.

VI.1.a.vi. BAD SPOT PATTERN

- Check the beam profile at the output of the optical head. If the beam profile is not good (means the burn patterns is filled-in, as described in Paragraph V.1), call QUANTEL service department.

- Check the flashlamp voltage on the RB (see Paragraph III.3.d.iv).

- Check the Q-Switch time delay on the RB (see Paragraph III.3.d.iv and figure III.6).

- Replace the flashlamp as described in the Paragraph V.2.

- If the energy stays bad, please call QUANTEL service department or its representative.

VI.2. ELECTRONICS TROUBLESHOOTING

To avoid false diagnosis when the LED associated to a given function is not lit, check the LED's status by switching the laser off and on. Just after switching the key "ON", all LEDs must light. If a specific LED is not lit, the corresponding function may operate anyway. All the light indicators cited below are located on the Remote control Box (RB). However, the following message will be displayed “Please change lamp and maintain CGU” without any interlock warning. This message allows you to continue (press ENTER), and is present to warn you to replace flashlamp (see section V-1 b).

VI.2.a.i. LCD REMOTE BOX MESSAGES

Power indicator of the Remote Box is off (see **1** of Figure III-5). Check the following points:

- Verify that the RB connector is plugged into the front panel of the ICE.
- The main AC power source.
- The manual capacitor switch has to be in the pulled position.
- The main fuse on the rear panel of ICE.

When a safety interlock detects a malfunction the name flashes and the recommended action are displayed on the screen of the RB. The following interlocks may detect a malfunction:

VI.2.a.ii. INDICATORS OF THE REMOTE BOX

Check those indicators to see if the laser is operating normally. After pushing the **ready** button (see **7** of Figure III-5), if the **ready** indicator does not light up, check the following points :

1. Verify that the **interlock** LED is lit.
2. Repeat the start-up procedure by switching off the key and ... (see chapter IV-2), and verify the **ready** LED lights up when the key is turned ON.
3. If the LED does not light up when the key is turned ON, the LED is out and the Simmer current may start. Push the **start** button of the flashlamp and observe the flashlamp operation.
4. If the LED is not out, repeat start-up procedure 3 times.
5. If the LED is still off push the **start** button of the flashlamp and observe the flashlamp operation.
6. If the LED is still off shut down the laser and follow the procedure for flashlamp replacement (see chapter V-1-b). Check if the flashlamp is broken.

After pushing the start buttons, if those indicators light up but there is no Flashlamp or laser output, check the RB to verify that the internal mode is activated. In external mode, check if the input signals parameters are as specified in chapter III-3-a-iii and on Figure III-2 & 3.

VI.2.b. LASER HEAD INTERLOCKS

LCD Message displayed	Advised actions
interlock: emergency stop push button see user manual	*Emergency stop push button: pull it to active position (RB)*
interlock: BNC intlk in on ICE front panel see user manual	*Ckeck "BNC interlock in" on ICE front panel.*
interlock: thermal sensor on laser head see user manual	*Thermal sensor on laser head fault, contact Quantel service department*
interlock: laser head housing opened see user manual	*Check Laser head top cover plate*
interlock: laser head housing opened see user manual	*Check protective housing on ICE*
interlock: controller bus error see user manual	*Internal or external I2C bus error on CPU*
flashlamp disabled time out delay expired	*End of time out function: see chapter III.3.b.v*

VI.2.c. ICE COOLING INTERLOCKS

LCD Message displayed	Advised actions
interlock: Thermal sensor see user manual	*Cooling group heater temp. too high contact Quantel service department*
interlock: charger over temp see user manual	*Electronics board temperature too high, contact Quantel service department.*
interlock: low water temperature see user manual	*Water temp. needs to be > 32°C for flashlamp start, wait a few more minutes. If the temperature is not increasing, please contact Quantel Service department.*
interlock: high water temperature see user manual	*Water temperature too high (> 45). Please wait for a natural temperature decrease and contact Quantel Service Department.*
interlock: low water level ICE cooling see user manual	*Water level sensor on ICE cooling system detects low water. Add a small amount of water using the fill kit. If the problem persists, please contact Quantel Service Department.*
interlock: low water flow see user manual	*Water flow meter detects low flow (<1 l/min), Check that the pump is operating, attempt to restart it with the Remote Box, if no success, please contact Quantel Service Department.*

VI.2.d. SOFTWARE CONDITIONS & PS ELECTRICAL INTERLOCK

LCD Message displayed	Advised actions
interlock: PSU charge error see user manual	*No end of charge received, Press ready button to charge the capacitor repeatedly. If no success contact Quantel service department.*
interlock: Voltage over settings see user manual	*Capacitor voltage too high, Press ready button to charge the capacitor three times. If no success contact Quantel service department.*
interlock: simmer stop see user manual	*Simmer current stops while firing. Press ready button to restart simmer. If no success contact Quantel service department*
interlock: low frequency see user manual	*In external synchro mode: the frequency is below the preset value F-10%.*
interlock: high frequency see user manual	*In external synchro mode: the frequency is above the preset value F+10%*
interlock : no flashlamp fire allowed see user manual	*Voltage problems. Press ready button to charge the capacitor three times. If no success contact Quantel service department.*
simmer disabled time out delay expired	*Simmer timeout expired: see chapter III.3.b.v*

VI.2.e. Q-SWITCH INTERLOCK

Flashlamps flashes but the Q-switch cannot be activated from the RB (no flashing of the Q-switch start LED)

LCD Message displayed	Advised actions
Q-S disabled Please wait 8s	*Normal interlock, wait while lamp flashes for 8s to enable QS*
Q-S disabled Water Temperature < 35°C	*Water temp. must be >35°C for Q-S to start. , wait a few more minutes. If the temperature is not increasing, please contact Quantel Service department.*
Q-S disabled time out delay expired	*Q-switch timeout expired. See chapter III.3.b.v*
Q-S disabled Please open Beam Shutter on optical head	*Q-S is not allowed to start with shutter closed. Open it to enable Q-Switch*

If any of those interlocks remain unsatisfied, please contact Quantel service department.

To Call QUANTEL SERVICE:

QUANTEL HEADQUARTERS (Worldwide)
2, bis avenue du Pacifique – Z.A. de Courtaboeuf
BP 23 – 91941 Les Ulis Cedex – France
Phone: +33 (0)1 69 29 16 10
Fax : + 33 (0)1 69 29 17 29
service@quantel.fr

QUANTEL USA (North America)
601 Haggerty Lane
Bozeman, MT 59715 – USA
Service Toll Free: +1 800 914 8216
Fax: +1 406 522 2007
customerservice@quantelusa.com

http://www.quantel-laser.com

VII. APPENDIX

VII.1. WARRANTIES

Unless otherwise specified, all mechanical and electronic parts and assemblies manufactured by QUANTEL are warranted to be free from defects in workmanship and materials for a period of one (1) year following delivery of the equipment to the FOB point. Warranty on optical components is one (1) year. In some countries, the warranty terms can be modified. However, the flashlamps of a QUANTEL laser, unless otherwise agreed to in writing, are guaranteed for 30 million shots for >80% of the output energy with voltage adjustement if necessary or 1 year whichever comes first.

VII.1.a. LIMITATION OF REMEDY

The exclusive remedy available upon breach of this warranty shall be the repair of the defective material so long as the following are observed:

1. This warranty does not apply to equipments or components which inspection by QUANTEL shall disclose to have become defective or unworkable due to abuse, mishandling, misuse, accidental alteration, negligence, improper operation or other causes beyond QUANTEL's control.

2. This warranty shall not apply in the event that the original device identification markings have been removed, defaced or altered or if any parts have been substituted or modified without the express consents of QUANTEL.

3. The customer's general account at QUANTEL is current and not delinquent in whole or in part.

VII.1.b. DISCLAIMER OF IMPLIED WARRANTY

The foregoing is in lieu of all other warranties Expressed or Implied, and there are no warranties of merchantability or fitness or any other remedies available other than as expressed herein.

VII.2. RETURNS, ADJUSTMENTS AND SERVICING

- If warranty or general repair or service to a QUANTEL product is requested by the customer involving the product's return to QUANTEL, the terms of the return shall include the following:

- The customer shall obtain written authorization for the product's return from the QUANTEL service manager.

- The product must be properly packed in the original QUANTEL shipping container. All water must be removed from the water-cooled products prior to packing.

- Freight and insurance (for the full value of the shipped goods) charges must be prepaid by the Buyer and all risk of loss, damage or delay in shipment shall be bore solely by the Buyer.

- After receipt of product, QUANTEL reserves the right to inspect the product and to determine the cause of failure and warranty status. QUANTEL shall have no duty to perform a warranty repair where the product has suffered damage in shipment that prevents a determination by QUANTEL of the cause or existence of the asserted defect under warranty.

- If the product is found to be under warranty it will be repaired or replaced free of charge in accordance with the terms of the QUANTEL warranty. The warranty period on a repaired or replaced product shall be the balance of the warranty period is remaining on the original product, i.e. no new warranty is created by such a repair.

- If the product is determined to be of a non-warranty status the customer will be advised and a written purchase order for the repair or service work will be required before the work begins. The cost and terms of non-warranty service shall be according to QUANTEL's then prevailing policies which are subject to change from time-to-time

- If the system is still under warranty, Freight and insurance (for the full value of the shipped goods) charges must be prepaid by the Buyer for the system shipment to Quantel and all risk of loss, damage or delay in shipment to Quantel shall be bore solely by the Buyer. Quantel pays the Freight and insurance (for the full value of the shipped goods) charges for the system return shipment to the buyer and all risk of loss, damage or delay in return shipment shall be bore solely by the Quantel.

To Call QUANTEL SERVICE:

QUANTEL HEADQUARTERS (Worldwide)
2, bis avenue du Pacifique – Z.A. de Courtaboeuf
BP 23 – 91941 Les Ulis Cedex – France
Phone: +33 (0)1 69 29 16 10
Fax : + 33 (0)1 69 29 17 29
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Fax: +1 406 522 2007
customerservice@quantelusa.com

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