Prima

3-Color Picosecond Laser

PicoQuant

Pulsed, CW, and fast switched laser
with variable operating wavelength

User Manual

Document version 1.0.1

Table of Contents

1.   General safety information

CAUTION! Before using this device, make sure that you have read and understood the content of this user manual. Store this documentation in a safe and easily accessible place for future reference.

Incorrect handling of this product may result in personal injury or physical damage. The manufacturer assumes no responsibility and cannot be held liable for any injury / damages resulting from operating the device outside of the normal usage defined in this manual.

1.1.   Warning Symbols and Conventions

The following symbols and conventions will be used throughout this manual. Please take time to familiarize yourself with their meaning before proceeding.

	The **general safety alert symbol** is used to alert you to hazards that may lead to personal injury or physical damage. Follow all associated safety instructions to avoid possible injury or death.
	A **high voltage warning symbol** is used to indicate the presence of un-insulated, dangerous voltage inside the enclosure. Note that this voltage may be sufficient to constitute a risk of shock.
	The **laser radiation warning symbol** alerts you that the device can generate laser radiation. Follow all applicable laser safety instructions to avoid injury or damages.
	The device's susceptibility to electrostatic discharge (ESD) is indicated by the **ESD warning symbol**. Ensure that you follow proper ESD protection rules to avoid damaging the device.
CAUTION!	Make sure to follow any instructions prefaced with "**CAUTION!**" to avoid personal injury or damaging the device.
WARNING!	The "**WARNING!**" label prefaces any instructions that shall be followed to avoid severe injury or death.
NOTICE	Important tips and information for device operation that do not include a risk of injury or damage are prefaced with the "*NOTICE*" label.
	This symbol indicates that an earth terminal shall be connected to the ground (to avoid risks of electrical shock).

1.2.   Electrical Safety Instructions

WARNING! To avoid electric shock, the power cord's protective grounding conductor must be connected to the ground. This device contains no user serviceable components. Do not remove covers! Servicing of internal components is restricted to qualified personnel.

Disconnect the power cord from the electrical outlet before performing any maintenance.

1.3.   Laser Safety Instructions

WARNING! Visible and invisible laser radiation

The Prima can be equipped with laser diodes that can emit visible, infrared, or UV light. Infrared or UV light is not visible to the eye! **The Prima laser module can emit laser light of up to class 3b / IIIb.** Please refer to the labels affixed to the laser for information on classification.

Lasers can be hazardous and have unique safety requirements. Permanent eye injury and blindness is possible if lasers are used incorrectly. Pay close attention to each safety related CAUTION and WARNING statement in the user manual. Read all instructions carefully BEFORE operating this device.

The Prima laser products are manufactured according to the International Laser Safety Standard IEC 60825-1:2014 and comply with the US law 21 CFR §1040.10 and §1040.11.

Required Laser Safety Measures

Please observe the laser safety measures for class 3b / IIIb lasers in accordance with applicable national and federal regulations. The owner / operator is responsible for observing the laser safety regulations.

What does the owner / operator have to observe?

- The owner / operator of this product is responsible for proper and safe operation and for following all applicable safety regulations.

- The owner / operator is fully liable for all consequences resulting from the use of the laser for any purposes other than those listed in the operating manual. The laser may be operated only by persons who have been instructed in the use of this laser and the potential hazards of laser radiation.

- The owner / operator is responsible for performing and monitoring suitable safety measures (according to IEC/EN 60825-1 and the corresponding national regulations).

- The owner / operator is also responsible for naming a laser safety officer or a laser protection adviser (according to the standard IEC/EN 60825-1: "Safety of laser products, Part 1: Classification of systems, requirements and user guidelines" and the respective national regulations).

The following security instructions must be followed at all times.

General Safety Instructions for Operation

- Never look directly into a laser beam or a reflection of the laser beam. Avoid all contact with the laser beam.

- Do not introduce any reflective objects into the laser beam path. This includes jewelry, watches, etc.

- Every person involved with the installation and operation of this device has to:

    ○ Be qualified

○   Follow the instructions of this manual

•   As it is impossible to anticipate every potential hazard, please be careful and apply common sense when operating the laser diode heads and associated driver unit. Observe all safety precautions relevant to Class 3b / IIIb lasers.

CAUTION!	**Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.**

1.4.   Laser Safety Labels

On the Laser Device

The safety labels are affixed to the top and side of the laser module's housings, with an arrow pointing towards the laser emission aperture (highlighted by red boxes in Fig. 1). The label states the laser product classification, certification, power, and wavelength range relevant for the classification.
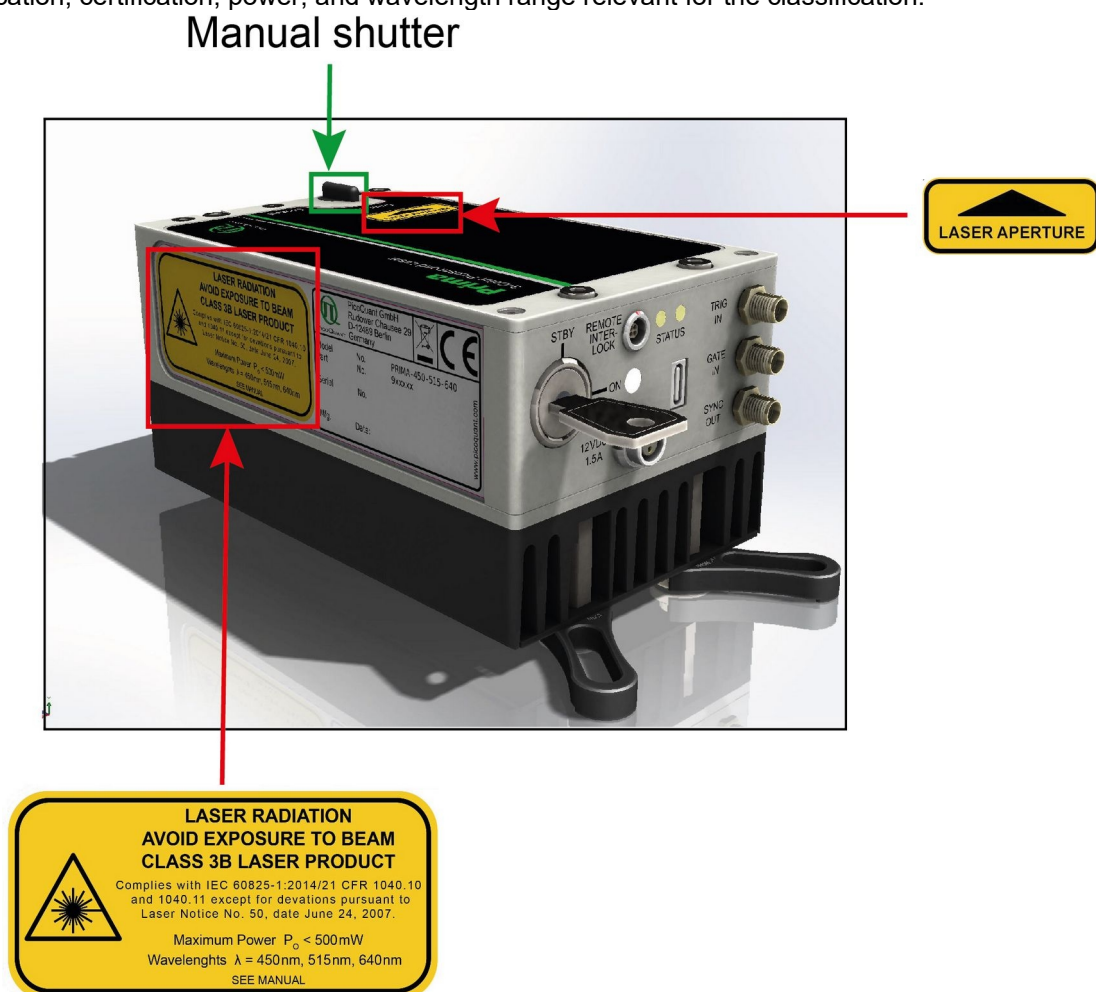
Fig. 1: Laser warning label, laser aperture indicator label, and manual shutter as well as their location on the Prima laser module housing.

Please refer to the *laser delivery report* in the Appendix for information on the central emission wavelengths, maximum achievable optical output powers, and pulse shapes of your Prima laser module.

The Prima 3-color picosecond laser module also features a manually operated mechanical shutter (highlighted by a green box in Fig. 1). The shutter is operated by turning the black lever into the desied position:

•   If the lever points towards the setting **CLOSED**, then laser emission is mechanically **blocked**.

•   If the lever points towards the setting **OPEN**, then laser emission is **not blocked** by the shutter

> **WARNING!** Laser light can be emitted from the aperture when the shutter is open. Ensure that all applicable laser safety measures are observed before opening the mechanical shutter.

1.5. Remote Interlock Connector

A hardware lock as well as a remote interlock connector are part of the Prima 3-color pulsed laser. Removing the green interlock connector (LEMO plug) or breaking the interlock circuit will immediately deactivate the power supply of the laser.

> **CAUTION!** The Prima will resume laser emission as soon as the remote interlock circuit is closed or once power is restored after a power loss. An open Interlock circuit (or activated Soft Lock) is indicated by white blinking "ON" LED.
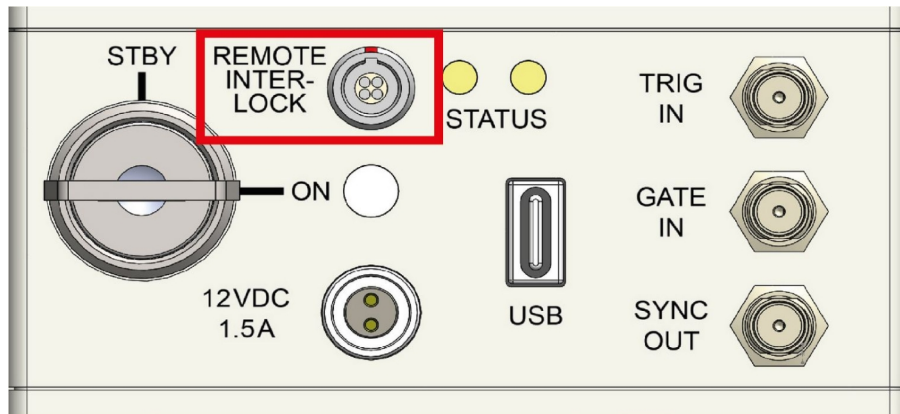
Fig. 2: Location of the remote interlock connector (highlighted with a red box) on the control panel of the Prima.

The remote interlock connector (LEMO connector) is located on the front panel as shown in Fig. 2.
In order to meet laser safety regulations, you may need to install a remote interlock, e.g., a door switch, to deactivate the power to the laser when the door to the laser area is opened.

Pin assignment for the interlock

The interlock is a 4 pin LEMO EGG.00.304.CLL female connector as shown in . In order to activate laser emission, **pins 2 and 3** need to be bridged using a suitable adapter. Do **NOT** apply any voltage.
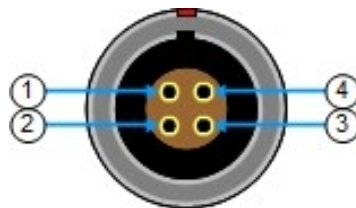
Fig. 3: Interlock LEMO connector

> **CAUTION!** A green LEMO plug is delivered with the laser driver, which bridges pins 2 and 3. Using this bridging plug is NOT intended for everyday use of the laser driver. The bridging plug cannot act as a functional remote interlock circuit, since it has no capability to react to e.g., a door switch.

2. Introduction

Prima is a compact, stand-alone, and affordable laser module offering 3 individual emission wavelengths that can be operated in picosecond pulsed and continuous wave (CW) mode. The picosecond pulses can be triggered either by the module's internal clock or by an external oscillator at up to 200 MHz. The module is fully computer controlled, making its operation very easy: Connect Prima to a PC via an USB port and all changes in operation parameters can be done via a convenient software interface.

Red, green, and blue: three commonly used wavelengths

Prima provides laser light at three wavelengths commonly used in materials science, chemistry and life science: 635, 515, and 450 nm. Each color can be generated individually, one at a time.

These wavelengths are very often used in material science, chemistry and life science for routine excitation in spectroscopy or microscopy applications to study a wide range of samples, including novel nanomaterials, quantum dots, molecules, and fluorophores.

Prima is the perfect tool: Capable of covering most of your needs when it comes to daily lab tasks, such as lifetime or quantum yield measurements, photoluminescence, and fluorescence.

Pulsed, CW, and fast switched emission modes

No matter what type of operation mode you need, Prima offers full flexibility, enabling time-resolved or steady-state measurements as well as use of fast CW switching capability. The pulsed mode can be driven either internally at selected repetition rates between 1 kHz to 200 MHz or externally, with rates ranging from single shot up to 200 MHz.

Each wavelength can achieve an average optical output power of typ. >10 mW. In CW mode, higher average power (up to 50 mW) can be reached for each individual wavelength. Switching the CW emission between ON and OFF states has a rise/fall time of less than 3 ns.

While constant repetition rates can be set internally, burst excitation patterns can be triggered from a suitable trigger source (such as e.g., the oscillator module of PicoQuant's Sepia PDL 828). You can even combine Prima with other laser diode heads to create even more sophisticated excitation patterns, including not only bursts but also Pulse Interleaved Excitation (PIE) or Alternative Laser Excitation (ALEX). This makes Prima a versatile tool that can be used in many environments.

Easy to use

Being a stand alone module, Prima does not require any additional laser driver. Settings and operating parameters are fully computer controlled via an intuitive control software based on the well-known Sepia graphic user interface.

3.   Hardware Description

3.1.   Interface Panel

| NOTICE	The front panel does not feature any manual controls for setting the operating parameters (e.g., intensity, repetition rate, selecting the trigger source) of the Prima. These settings must be performed via a Graphical User Interface (GUI), see section 5.2 for more details. However, the laser device may be used without connection to a PC. The Prima will then be running with the last set of operational parameters that were saved to its memory.
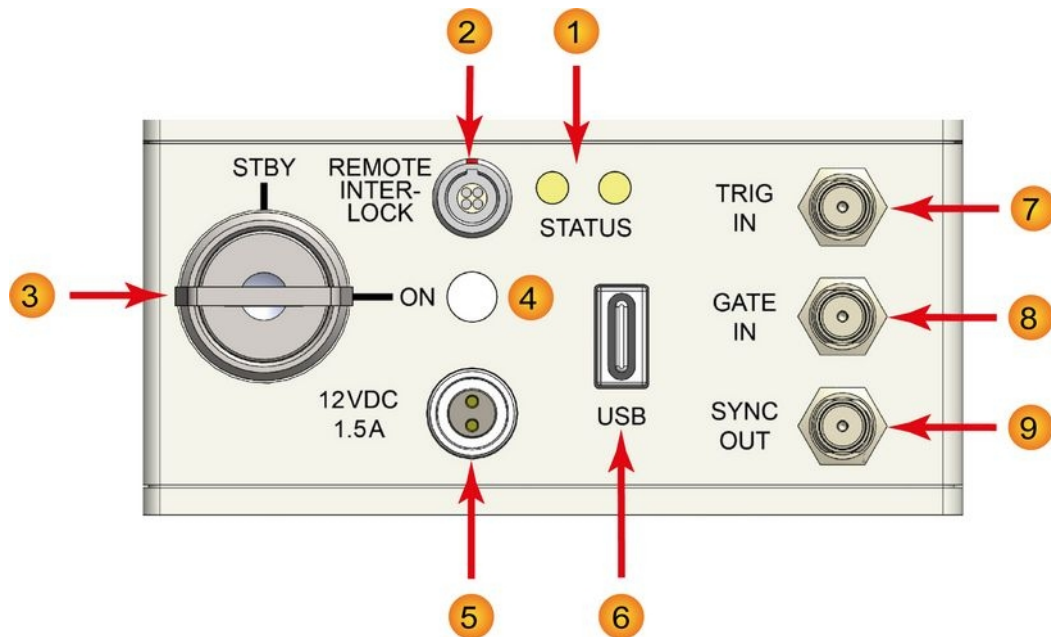
Fig. 4: Interface panel

①   **Status indicators**. These two LEDs provide information on the general operation status (left LED) as well as on the emission mode and trigger status (right LED)

Left LED (status indicator): When the Prima is powered on, this LED should light up and flash first in red, then yellow and finally green. After approximately 15 seconds, this indicator should permanently show green. .If the status indicator shows red for more than 2 seconds, then an internal error occurred. The exact nature of the error can be read out via the software API. Please refer to the PQLaserDrv API Manual for more details.

Right LED (emission mode and trigger status): This indicator lights up in blue when when Prima is operated in pulsed mode and in orange when running in CW mode. Note that the LED will only be lit when a valid trigger signal (either internal or external) is present and is independent of the key switch ③ position. When operated at either very low repetition rates, long gating periods, or with invalid trigger level, the indicator will turn off after about 100 ms until the next event turns the LED back on.

②   **REMOTE INTERLOCK** socket for remote interlock connector (see section 1.5).

③   **Key switch** (laser switch): Turning the key to the *ON* position activates the laser. Power to the laser can be locked off by turning the key to the *STBY* position and removing the key.

④   **Laser emission indicator**. This white LED serves as an indicator of whether the Prima laser module is emitting laser light or not. The various laser states and LED behavior are summarized in the table below:

LED behavior		Laser emission state	Condition
OFF	constant OFF	No laser emission	Key switch = STBY or Laser Soft Locked or Power supply not connected
White	blinking ~0.3sec	No laser emission	Key switch = ON and Interlock not connected (resumes emission automatically when Interlock is connected!)
	constant ON	Laser active	Key switch = ON and Interlock connected

⑤   Main **POWER** input socket for the power supply.

⑥   **USB-C** connector to interface the Prima with the PC

NOTICE   Changing the operational parameters of the Prima requires a connection via USB 2.0 interface to a PC, that runs a compatible software application (e.g., PicoQuant's `PQLaser-Drv.exe`).

⑦   **TRIGGER IN***: external trigger input with variable trigger threshold (female SMA connector)

⑧   **GATE IN**: gating input (female SMA connector)

The gating function affects the triggering mechanism. The gating input accepts TTL pulses and is effective if the Prima is being triggered either from the internal oscillator or from an external source. The gating function can perform transition between on and off states within nanoseconds. Presuming a precise timing, it can switch in between two laser pulses, even at high repetition rates.

⑨   **SYNC OUT***: Synchronization output connector (female SMA connector)

3.2. Laser Locking Behavior

- The key switch ③ interrupts the laser power supply when it is in the horizontal position. The key can be removed only in this position. It's a good practice to keep the key switch locked unless the Prima can be operated according to safety regulations.

- The remote interlock ② shuts the laser power supply off when the loop current is interrupted.

- To comply to the laser safety regulations, laser emission is locked off for at least the first 10 seconds after the main power has been switched on.

- Laser emission is locked off as long as the Prima checks its hardware while powering up.

- The Prima keeps laser emission locked off, if it detects any abnormal operating conditions.

- Losing the trigger signal when the Prima is triggered externally will NOT activate the hardware lock.

- The controller can be instructed from the GUI or from any software using the programming library (API DLL) to hold the lasers locked off regardless of the position of the key switch. Refer to section 5.2.3 (GUI) and the separate API manual for more information on soft locking.

WARNING!   **Soft locking the lasers does not ensure eye safety!**

3.3. Optical Output

The Prima *features* one optical free beam output equipped with a manually controlled laser output shutter.

The laser output can be coupled into either multi mode (MM) or polarization maintaining (PM) single mode fibers.

If a fiber coupler is attached to the output:

- The fiber type used is indicated in the individual test report (see appendix).

- Do not remove the fiber from the coupling optics since this will lead to a loss of the coupling adjust-ment! Re-adjustment is a demanding task and needs experience.

3.4.   Product Label

The product label (see Fig. 5) can be found on the side of the Prima module, next to the laser safety label . It shows all relevant information needed to identify the device, including product name, part number, serial number, manufacturing date as well as the PicoQuant logo with address, CE label, and waste regulation iden-tifier.

	PicoQuant GmbH Rudower Chausee 29 D-12489 Berlin Germany		CE
Model	No.	PRIMA-450-515-640	
Part	No.	9xxxxx	
Serial	No.		www.picoquant.com
Mfg.	Date:		
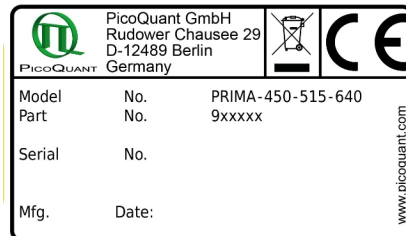
Fig. 5: Prima product label

This product information must be communicated to PicoQuant in all communication and trouble shooting pro-cesses regarding this device.

3.5.   Cooling Fan – Heat Dissipation

A special design for heat dissipation is required to ensure stable laser emission. The laser module is there-fore equipped with cooling fans on the heat sink locale at the bottom of the casing.

For best laser performance and stability, please ensure free air circulation around the whole laser module. By default, the cooling fans will be running when the Prima is powered on and the fans **cannot** be switch off dur-ing operation.

A note regarding vibration sensitive measurements: All tests made at PicoQuant have never shown any noticeable effect of fan vibration on such measurements.

> **CAUTION!** **Do not block the fan apertures. This might lead to laser instabilities or damage to the laser module!**

4. Installation

4.1.   Unpacking and Preparations

Your Prima is delivered with a series of cables, accessories, and software that need to be connected / installed before the device can be used. Start by unpacking the delivery box and check that all components listed in the table below are present.

Prima 3-color picosecond laser

This printed manual

Remote interlock stub plug (4 pin LEMO plug with green end cap)

2 keys for the laser keyswitch

Cable USB 3.0 C MALE TO USB 3.0 A MALE (2 m, 6.5x ft)

Power supply with power cable featuring appropriate mains plug (cabel not shown)

Installation medium for the operational software (CD)

Before installing and using the Prima, please make sure to have

1. a solid base onto which the Prima can be placed (e. g., an optical table)
2. a computer to install and run the operation software. The computer needs to have a free USB slot as well as a Windows 10 operating system.

Make sure that all of the following conditions are met before proceeding with the installation (numbering refers to the front panel as shown in Fig. 8):

- Laser key switch ③ is set to the position **STBY** (vertical)

- Green remote Interlock stub connector is plugged into the remote interlock socket ②

4.2.   Electrical Power and Signal Connections

- If desired, connect an external trigger signal to the connector labeled **TRIGGER IN** ⑨

- If desired, connect the **SYNC OUT** output connector 12 to an external device, e.g., TCSPC electronics from PicoQuant such as the TimeHarp 260, PicoHarp 300, MultiHarp 150, HydraHarp 400, or an oscilloscope

- Plug the power cable into the **main power socket** 5 But do not plug the power cable into a power outlet before installing the PicoQuant laser driver software (see section 4.3)

4.3. Software Installation

Once the Prima is in its dedicated place and the relevant cables have been inserted, connect the Prima to the host computer using the delivered USB C cable.

NOTICE	The Prima should not be powered on before the control software is installed on the host computer!

The control software "`PQLaserDrv.exe`" for your Prima and other laser drivers manufactured by PicoQuant needs to be set-up by an installer and is supplied on the CD along with your device. Installing the software is straightforward and performed by a step-by-step installation wizard.

NOTICE	In order to future-proof the software, a switch to a new USB driver architecture is required **starting with software version 1.2.xx.636** (changing from PQUSB to WinUSB). The two driver architectures are **NOT** compatible with each other. This means that once the new drivers have been installed and they have registered the PicoQuant laser driver(s), software packages relying on the older drivers will no longer be able to "see" or connect to these USB devices. The reverse is also true: i.e. a software package relying on the newer drivers will not be able to discover or communicate with laser drivers registered to the older USB driver architecture. An important consequence of this is that both the PQLaserDrv package as well as any software package requiring a connection to a PicoQuant laser driver (i.e. SymPhoTime 64 or EasyTau) should be fully updated together.

To install the software:

1. Insert the installation medium into the host computer
2. Launch the program: `PQLaserDrv_Setup.exe`
3. Follow the instructions on the screen
4. Accept the License agreement and click *Next* when requested
5. Define the destination folder for the installation of the software
6. Select the components to be installed (availability of which can change depending on product releases or discontinuations)
7. Select which launcher icons will be generated
8. Validate your choices by clicking on *Next* and then click on the *Install* button to start the installation

Important Remarks:

The PicoQuant Laser Driver Software can control not only the Prima but also the Sepia devices from PicoQuant. In case you need to control multiple lasers, then it is necessary to install all relevant components (see point 6 in the above list).

It is recommended to choose at least one of the suggested icon options. For each icon option chosen, the installer automatically creates two software launchers corresponding to the "Bright" and "Dark" PicoQuant color themes. For more details about the software color themes please refer to section 5.2.

9. Click *Next* to start the installation of the drivers. It is possible that a *Windows Safety Warning* windows pops up. In that case confirm the installation when requested in order to continue with the installation.
10. Click *Next* when requested to complete the installation
11. Click *Finish* to close the Installation wizard

Once the software is installed, the Prima can be turned on (see chapter 5.1). When the laser is powered on for the first time, Windows will detect a new device and install the necessary device drivers.

5. Operation

This section describes detailed step by step operation procedures for powering the Prima on as well as on how to use the GUI for setting the different laser module settings (i.e. power intensity, trigger source, repetition rate, fan control).

5.1. Powering the System On

1. Make sure the key switch ③ in on *STBY* position

2. Make sure that the remote interlock connector ② in place

3. Connect the external power supply to ⑤ and the power outlet to start up the Prima. The left status indicator LED will light up blinking orange and green until constantly green.

   After about 15 seconds the system is ready for operation.

4. Turn the key switch to the *ON* position. The LED labeled **ON** ④ will turn white.

   In order to reach stable output power, please let the Prima laser warm-up for about one minute before you activate laser emission through the key switch. The laser emission directly after start up will be automatically delayed for about 20 seconds even if the key switch is enabled.

> **WARNING!** **Before proceeding to the next steps, please make sure that all safety measures have been taken according to chapter 1.3 Laser Safety Instructions.**

5. Open the laser output shutter.
6. Adjust the operating parameters through the appropriate software (e.g. with PQLaserDrv.exe).

If you cannot detect a laser beam, please check chapter 3.1, point ①.

5.2. Setting Operating Parameters with PQLaserDrv Graphical User Interface

> **NOTICE** The Prima must be turned on and the initialization process completed, before the software can be started!

The GUI is available in three different **color schemes:** PicoQuant bright scheme, PicoQuant dark scheme and a standard Windows scheme. The latter can be customized using the standard Window control panel.

The dark scheme is intended for light sensitive set-ups and experiments such as, e.g., photon counting and single molecule sensitive spectroscopy set-ups, where ambient light perturbation should be minimized as far as possible. However, for better readability, all screen shots in this manual correspond to the PicoQuant bright color scheme.

The color scheme is applied by the command line parameter "`/style=<scheme>`" where the placeholder `<scheme>` could be one of the legal values "`dark`", "`bright`" or "`windows`".

During the installation setup of the software, the installer can optionally generate separate desktop as well as quick launch icons for the respective bright and dark schemes (see section 4.3).

In the interest of ergonomics, all relevant active controls (button, edit box, etc.) change color when the mouse pointer hovers above them.

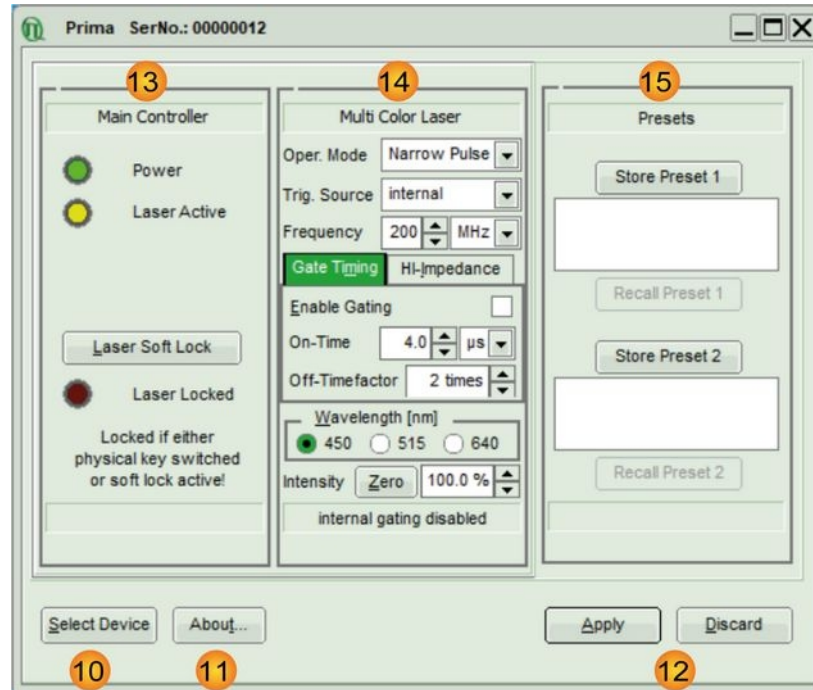An overview of the GUI with all control elements is shown in Fig. 6 below.

Fig. 6: PQLaserDrv GUI with a connected Prima 3-color laser - Overview of all main button and control groups

5.2.1. Select Device

The *Select Device* (10) function is useful if more than one Prima (or any other USB laser device from Pico-Quant) are connected to the same host computer. It can also be used to restore the USB connection to the device should it be lost during operation for any reason.

A mouse click on the *Select Device* button will start a scan for supported devices connected to the PC.

A modal dialogue with an *OK* and *Cancel* button presents a list box with the currently connected devices (Fig. 7). When opening the list box, all detected devices are listed by their serial number. The currently selected device is marked with an asterisk "*".
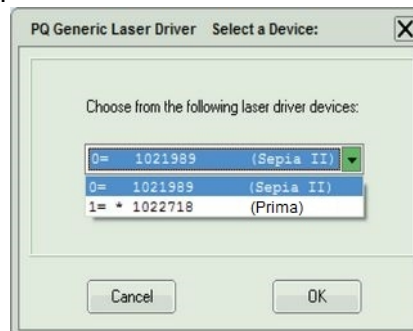

Fig. 7: Select device

Cancel	Back to the main window without any changes.
OK	Change to the newly selected device. Note that this might lead to changes in the GUI, if a device of different type or configuration is selected. The serial number of the cur-rently selected device is always displayed in the title bar of the software.

5.2.2. Apply / Discard

Apply and *Discard* buttons (11) must be used to confirm or discard the configuration changes made in the GUI. The label of any control panel where changes have been made but not yet committed, will highlighted in orange as well as the *Apply* button. These highlights remain until the changes are either applied or discarded.

5.2.3. Soft Lock and Unlock of the Prima

The Prima can be locked (no laser light emission) not only with the hardware key switch on the control panel, but also via the GUI by clicking on the button labeled *Laser Soft Lock / Laser Soft Unlock* in the Main Controller panel (12) on the left side of the software window.

The mechanism behind the soft lock is similar to that of an interrupt via the interlock loop.

WARNING! Soft locking the lasers does not ensure eye safety!

The *Laser Unlocked* state is recognizable in the software by the *Laser Locked* indicator turning dark red (see Fig. 8, left). In addition, the *"ON"* LED (4) on the Prima is blinking if the key switch is in ON-position, or off if key switch is in STBY-position.

The *Laser Soft Locked* state is recognizable in the software by the *Laser Locked* indicator turning bright red. The button text could be either *Laser Soft Lock* in case the system was hard locked by key or remote interlock circuit (see Fig. 8, middle), or *Laser Soft Unlock* (see Fig. 8, right) in case the system was soft locked (This even masks a hard lock state). In addition, the **key switch indicator** LED (4) on the Prima has light up white.

Please note that the lock state indicated in the GUI may refresh with a slight delay (< 1 s) with respect to the hardware LED on the front panel of the Prima. **Consider:** The soft lock state is not persistently stored in the system; It is lost after power down / power up.

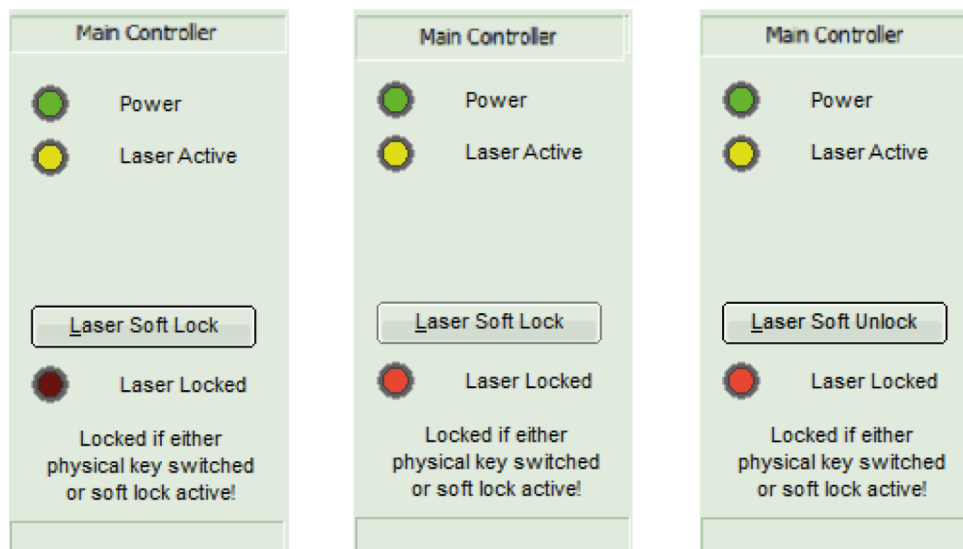| WARNING! Before unlocking the laser, please refer to chapter 1.3 for laser safety instructions. |
| --- |

Fig. 8: Prima locking status indicator in the GUI: laser unlocked (left), laser hard locked via key (middle), laser soft locked (right)

5.2.4. Multi Color Laser Control Panel

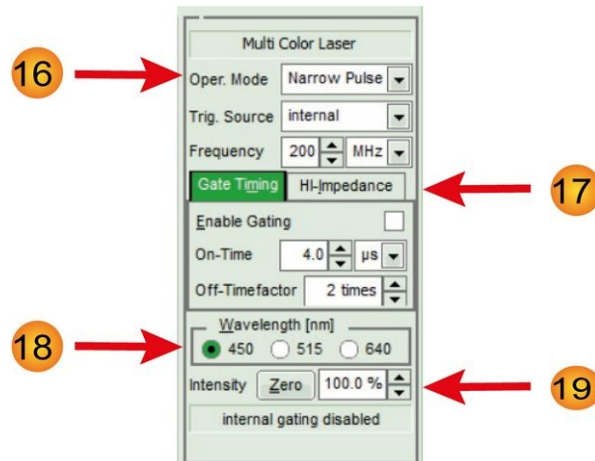Fig. 9 shows the laser control elements available for the Prima.

Fig. 9: GUI control panel for the Prima 3-colorpicosecond laser

(16)   **Oper. Mode:**

- Use the top selection box to choose the operation mode for the Prima. Note that the control elements located just below from the mode selection box will change depending on the chosen operation mode. The following operation modes are available for the Prima:

- *Off:* Selecting this option will turn laser emission off. No additional controls will appear below the selection box when the Prima's operating mode is set to *Off*.

- *Narrow Pulse*: this option enable the emission of picosecond laser pulses with narrow temporal pulse widths of < 80 to < 170 ps depending on wavelength. Pulses from the Prima 3-color laser module can be triggered either internally or externally.

   ○ After selecting *Narrow Pulse*, a new selection box called *Trig. Source* will appear below the mode selection box.

      ▪ Choose the option *internal* to use the Prima's internal clocks for triggering the picosecond pulses. Upon selecting this option, a spin edit box labeled *Frequency* appears, which allows setting the repetition rate from 1 kHz to 200 MHz (see Fig. 10). The frequency unit (kHz, or MHz) can be selected from the selection box next to it.
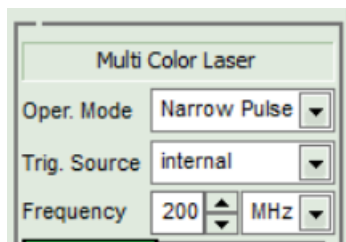

Fig. 10: Additional control elements for internal triggering in both narrow and broad pulsed mode

      ▪ Select one of the options e*xt. (NIM)*, e*xt. (TTL)*, e*xt. (falling)*, or e*xt. (rising)* to trigger the Prima laser module via an external signal source.

         • Choose e*xt. (NIM)* or e*xt. (TTL)* when using the corresponding signal type as trigger source. No additional control element will appear in this case. The pre-configured settings in the background read
            ext. (NIM): -0.4 V, falling edge
            ext. (TTL): +1 V, rising edge

         • The option *ext. (falling)* will trigger upon the falling edge of an electrical pulse, while *ext. (rising)* does the same on the rising edge of such a signal. Both of these options will also spawn an additional spin edit box called *Trig. Level*, where the threshold of the trigger signal can be set in V between -1 V to +1 V (see Fig. 11).
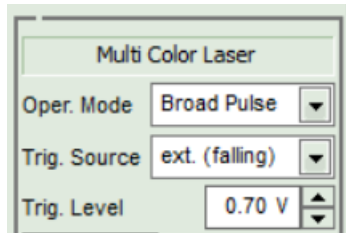
Fig. 11: Additional control elements
for external triggering in both narrow
and broad pulsed mode.

- *Broad pulse*: In this operation mode, the Prima will generate picosecond laser pulses in a similar way as in the *Narrow pulse* mode. The main difference being that pulses will have a higher optical output power but with a broader pulse width (typ. < 1 ns, depending on wavelength). Again, the pulses can be triggered internally or externally.

  - After selecting *Broad Pulse*, a new selection box called *Trig. Source* will appear below the mode selection box.

    - Choose the option i*nternal* to use the Prima's internal clocks for triggering the picosecond pulses. Upon selecting this option, a spin edit box labeled *Frequency* appears, which allows setting the repetition rate from 1 kHz to 200 MHz (see Fig. 10). The frequency unit (kHz, or MHz) can be selected from the selection box next to it.

    - Select one of the options e*xt. (NIM)*, e*xt. (TTL)*, e*xt. (falling)*, or e*xt. (rising)* to trigger the Prima laser module via an external signal source.

      - Choose e*xt. (NIM)* or e*xt. (TTL)* when using the corresponding signal type as trigger source. No additional control element will appear in this case.

      - The option *ext. (falling)* will trigger upon the falling edge of an electrical pulse, while *ext. (rising)* does the same on the rising edge of such a signal. Both of these options will also spawn an additional spin edit box called *Trig. Level*, where the threshold of the trigger signal can be set in V (see Fig. 11).

- *CW*: By choosing this option, the Prima will generate laser light as a continuous wave (CW).

  - In this mode, the laser produces no picosecond pulses. However, the laser can still be modulated on a longer time scale (i.e. 5 ns...1 ms) via internal gating or arbitrary length with external gating.

  - No additional controls will appear below the *Operating Mode* selection box when the Prima is running in this mode.

(17)   Gating and Gate Timing:

- Prima's laser emission can be gated both internally and externally, even simultaneously.(i.e. turned on and off in various pattern) in all emission modes.

- Internal Gating is activated by ticking the *Enable Gating* check box in this section of the control panel.

- The *On-Time* spin edit box allows setting the time period where the Prima is emitting laser light. The time unit (ns, µs, ms) can be selected from the selection box located next to it.

- The time period in which the laser emission is kept turned off is defined by the value in the *Off-Timefactor* spin edit box. The time period during which the laser will be equal to the *On-Time* value multiplied by the *Off-Timefactor*. The resulting duty cycle and period time is displayed at the bottom.

- External gating must be provided by a gating signal fed into the GATE IN input connector **(8)**

- The tab on the right side allows selecting the impedance for the applied external gating signal via two radio buttons: either *Low* (50 Ohm) or *High* (≥ 1 kOhm). Note that the tab's label will change accordingly to *HI-Impedance* or *LO-Impedance* depending on the chosen option. Please note, that setting impedance to *High* disables the laser emission until a valid external gating signal is provided, while setting to *Low* leads to classic emission gating.

- Note that the state of the internal gating (enabled or disabled) is displayed at the bottom of the *Multi Color Laser* control panel.

18 **Wavelength Selection**:

- The three radio buttons in the *Wavelength [nm]* section allow choosing the emission wavelength of the Prima 3-color picosecond laser. Note that switching the wavelength is not instantaneous. The laser module will require some time (typically <200 ms) before stable emission at the new wavelength is available

- The intensity setting will be stored in the Prima individually for each wavelength, however independent of the Oper. Mode.

19 **Intensity:**

- The intensity of the Prima's driving current can be set on a freely adjustable scale from 0 to 100 %, with a step width of 0.1%. Please note that the optical output power does not correlate linearly with the current intensity scale. Each wavelength has a particular threshold value for laser emission, a particular slope, and a particular maximal power value.

- The *Zero* button provides an easy toggle between any intensity value and zero intensity. This is useful in case the Prima needs to be switched off quickly. The button stores the intensity previously set, which is also shown by changing the buttons name from *Zero* to the that percentage value. Pressing it again restores this intensity setting (or vice versa).

NOTICE	When entering an invalid intensity value (i.e. outside of the 0 to 100% range or with a step width lower than 0.1%), the edit box will show a red outline and the "Apply" button will be disabled.

5.2.5. Presets

Two working configurations can be saved and recalled in the control panel labeled *Presets* **15**. Each preset stores all working parameters of the device. The currently applied configuration can be saved by clicking on the *Store Preset 1* or *Store Preset 2* button (see Fig. 12). A pop up window gives the possibility to include a short comment with a maximal length of 64 characters for each stored configuration (see Fig. 13). A stored configuration can simply be recalled by clicking on the button labeled *Recall Preset 1* or *Recall Preset 2*.

Fig. 12: Save a configuration

Fig. 13: Edit comment for a preset

Note: The presets are stored in the internal memory of the device and not on the host computer. They can therefore also be recalled if the device is connected to a different host computer.

NOTICE	Clicking on a *Recall Preset* leads to an immediate configuration change without the need to manually apply the changes! The process itself can, however, take some time depending on the difference between current and recalled settings!

5.2.6.   "About..." button

Extended information about the device, including hardware version, serial number, operating hours, software and firmware version etc. can be brought up by clicking on the button labeled *About...* 11

For every support request its is recommend to save the entire information by clicking on the button labeled *Copy Support Infos* (see Fig. 14)*,* save the information as a plain text file, and send it per mail to
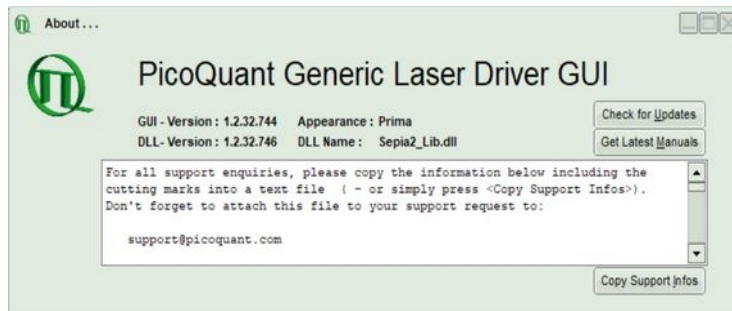
support@picoquant.com

Fig. 14: The "About" window includes extended information about the status of the device

It is also possible to search for possible software updates by clicking on the button labeled *Check for Updates* (Fig. 14). If an update is available, a download link to the latest version will be provided. The button labeled "Get Latest Manuals" will also check online if newer versions of applicable manuals are available. An example of such a search result is shown in Fig. 15.
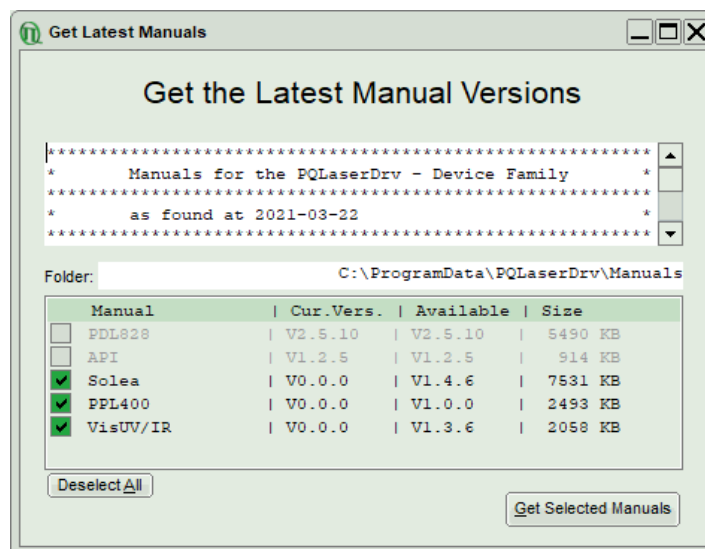

Fig. 15: A potential result screen after searching for latest manual versions

Lines corresponding to manuals that are up-to-date will be greyed out. Manuals that are currently not installed are listed as v0.0.0 in the column *Cur. Vers*.

To download the latest version of one or more manuals, tick the corresponding check-boxes and click on "*Get Selected Manuals*".

6.   Trouble Shooting, Tips and Tricks

6.1.   Power stability

Please allow a start-up and warm-up time of about one minute between powering up the laser module and activating it through the laser key switch. This thermal equilibration time will ensure the ideal stability of the optical output power.

6.2.   Pulse Repetition Rate and Intensity Settings

Changes to the pulse repetition rate have an impact on the total average output power of the laser. The pulsed average power is typically proportional to repetition rate, however pulse energy may not scale linearly especially at higher repetition rates.

The intensity setting allows for variation of the laser drive current under all operation modes. In CW mode, the power scales nearly linear. Under pulsed operation, the optical pulse energy is nonlinear related to the drive current and as such may shown a high threshold value and steep increase thereafter for the intensity setting.

7.   Technical Data / Specifications

Optical output (valid only for Prima-450-515-640, Part No. 912001)

Available wavelengths[1]........................ 450, 515, and 640 nm

Nominal max. pulsed power[2].............. 10 mW for each wavelength

Pulse duration..................................... < 120 ps for 450 nm; < 170 ps for 510 nm; < 120 ps for 635 nm

Nominal cw power.............................. 50 mW for all three wavelengths

Beam dimension[3].............................. 0.55 mm for 450 nm; 0.6 mm for 510 nm; 0.8 mm for 635 nm

Beam circularity................................. > 0.5 for 450 nm; > 0.6 for 510 nm; > 0.7 for 635 nm

Polarization.. Linear for all three wavelengths, horizontal

Polarization Exctinction Ratio (PER).... typ. > 1 : 10 (> 10 dB) for all three wavelengths

Spectral width (pulsed, FWHM)........... typ. 4 nm for 450 nm; 6 nm for 510 nm; 2 nm for 635 nm

Spectral width (cw, FWHM)................ < 1 nm for all three wavelengths

Repetition rates

Internal

Range.. user selectable in 1200 steps; 1...999 kHz and 1...200 MHz

External

Range.. single shot to 200 MHz

Trigger level....................................... -1 to +5 V into 50 Ohm

Jitter.. < 20 ps

Connector.. SMA

Synchronization input

Amplitude... < -800 mV into 50 Ohm (NIM)

Connector.. SMA

Gating

Optical rise / fall time........................... < 3 ns

Impedance... >1 kOhm with pull-up

.... 50 Ohm with pull-down

Connector.. SMA

Dimensions

Size (h x w x l).................................... 75 x 83 x 140 mm

Operation

Temperature range............................. 15 to 40 °C

Max. power consumption.................... < 30 W

---

1 Typical value in Pulsed mode. A slight shift to longer wavelengths in cw mode.

2 This is the maximum average power at maximum intensity setting and max repetition rate. A pulse broad-ening up to 1 ns FWHM is possible at maximum intensity setting.

3 Measured at 1 m distance from laser aperture

Interface

PC interface.. USB 2.0
Connector... USB-C
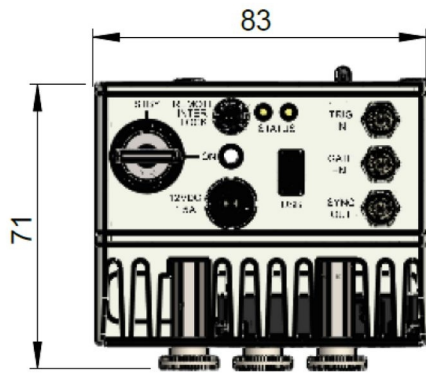Operating system................................ Windows™ 10

Retraction of Old Devices

Waste electrical products must not be disposed of with household waste. This equipment
should be taken to your local recycling center for safe treatment.
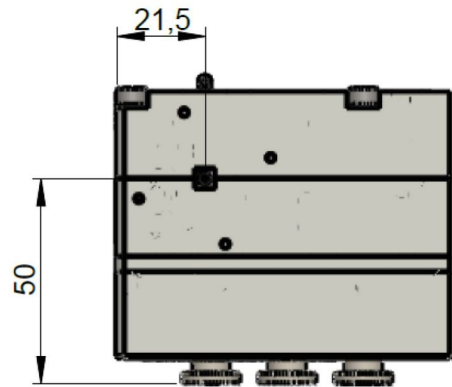WEEE–Reg.–No. DE 96457402

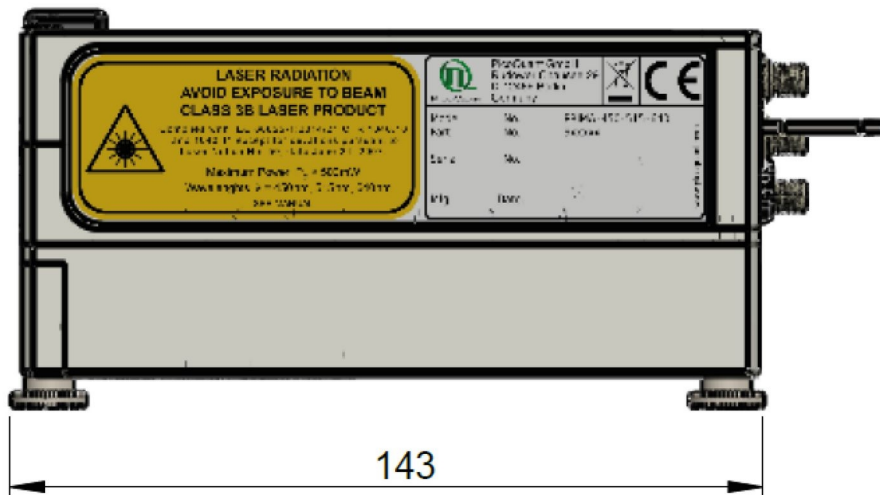**Dimensions of the Prima laser module (all values given in mm):**

Back   # Front

Side

8.   Support

8.1.   Returning Products for Repair

Should you encounter problems that require sending the device in for inspection / repair, please contact us first at: https://support.picoquant.com or support@picoquant.com and request an RMA number before shipping the device. Please include the serial number of your device. Observe precautions against static discharge under all circumstances during handling, packaging and shipping. Use original or equally protective packaging material. Inappropriate packaging voids any warranty.

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10. Further Reading

10.1. PicoQuant Bibliography

PicoQuant maintains a database of publications mentioning PicoQuant devices. It can be found at our web-site https://www.picoquant.com/scientific/references. It is a valuable source if you would like to know which laboratories are using PicoQuant products or how broad the field of various applications is.

10.2. Download of Technical Notes / Application Notes

PicoQuant, along with our customers, continuously writes and publishes short documents about techniques, methods and applications that are possible with our hardware or software. The download section can be found at https://www.picoquant.com/scientific/technical-and-application-notes

11.   Appendix

11.1.   Abbreviations

BNC	British Naval Connector or Bayonet Nut Connector or Bayonet Neill Concelman
CAMAC	Corporations and Markets Advisory Committee
FWHM	Full Width at Half Maximum
IEC	International Electrotechnical Commission
IR	Infra-red
IRF	Instrument Response Function
LED	Light Emitting Diode
MOFA	Master Oscillator Fiber Amplifier
NIM	Nuclear Instrumentation Methods
RMA	Return Merchandise Authorization
SMA	Sub-Miniature version A (connector type)
STED	STimulated Emission Depletion
TCSPC	Time-Correlated Single Photon Counting
TTL	Transistor-Transistor Logic
UV	Ultra-violet
VIS	Visible
WEEE	Waste Electrical and Electronic Equipment

11.2.   System Delivery Report

The delivery report of your laser, including all final production test results for pulse shape, optical power, and linewidth is attached to this user manual. A PDF copy can be provided on request.

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