USER GUIDE FOR THE

OPTOLUTION PIV SYSTEM

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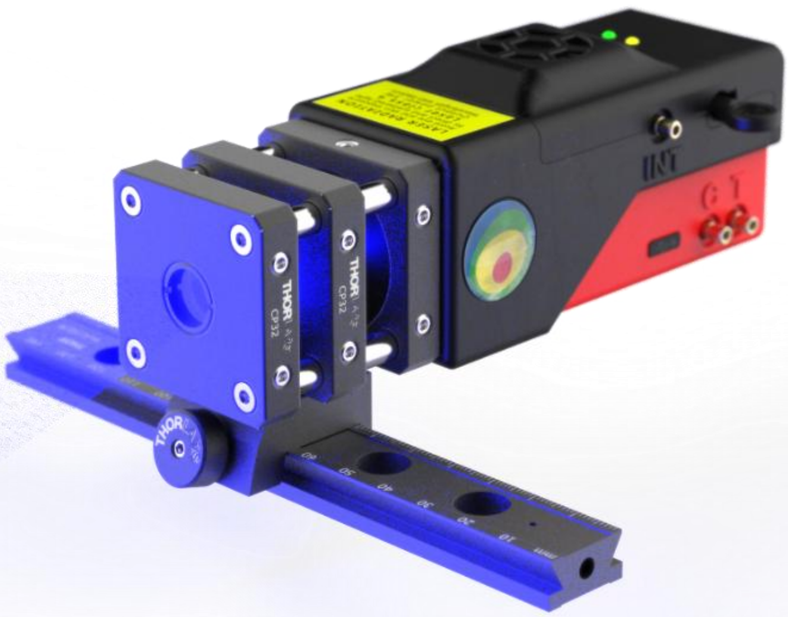

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SYSTEM OVERVIEW

The OPTOLUTION PIV system consists of several building blocks that can be combined to get the most suitable PIV setup.

Figure 1: The components of the OPTOLUTION PIV system.

GENERAL REMARKS

Our PIV system is tailored to be used with PIVlab, a free and open-source tool for Particle Image Velocimetry (PIV). PIVlab is available as standalone software for windows computers, or as Toolbox and App for MATLAB. There is also a web browser-based version available. The latest release can be found at https://www.PIVlab.de. The website additionally contains video tutorials, a wiki, screenshots of the graphical user interface, and links to thousands of studies conducted with PIVlab.

By using the Connector Breakout or the Synchronizer Dock, the OPTOLUTION PIV system can also be integrated and used with third party components, without using PIVlab.

COMPONENTS & PROPERTIES

LASER MODULES

Available in 500 mW (638 nm, Class 2M), 5 W (450 nm, Class 4), 20 W (450 nm, Class 4) and 40 W (450 nm, Class 4). The laser modules can be used with our synchronizer, or with a third-party pulse generator (Connector Breakout required). The modules can operate up to 50% duty cycle, and with a pulse repetition of up to 500 kHz. The minimum pulse length is 2 µs. All our laser modules come with integrated sheet optics that allow to focus the light sheet (0.7 – 1 mm thickness). The laser modules are equipped with the required key switch and interlock input.

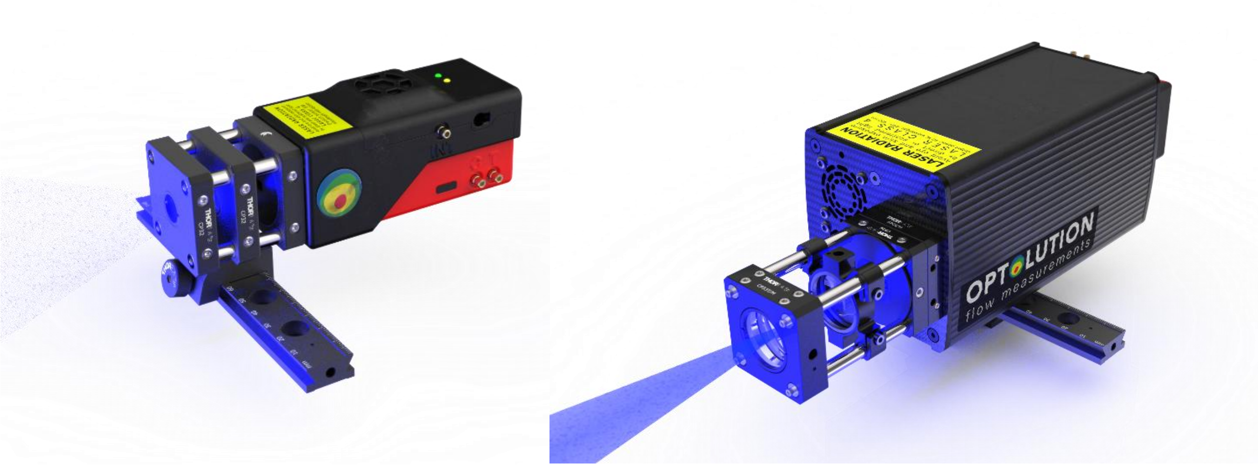

Figure 2: Left: 500 mW and 5 W laser module. Right: 20 W and 40 W laser module.

SYNCHRONIZER

The synchronizer is used to synchronize the camera exposure with laser pulses. This allows to use frame-straddling, which makes it possible reduce the interframe time and therefore the particle displacement.

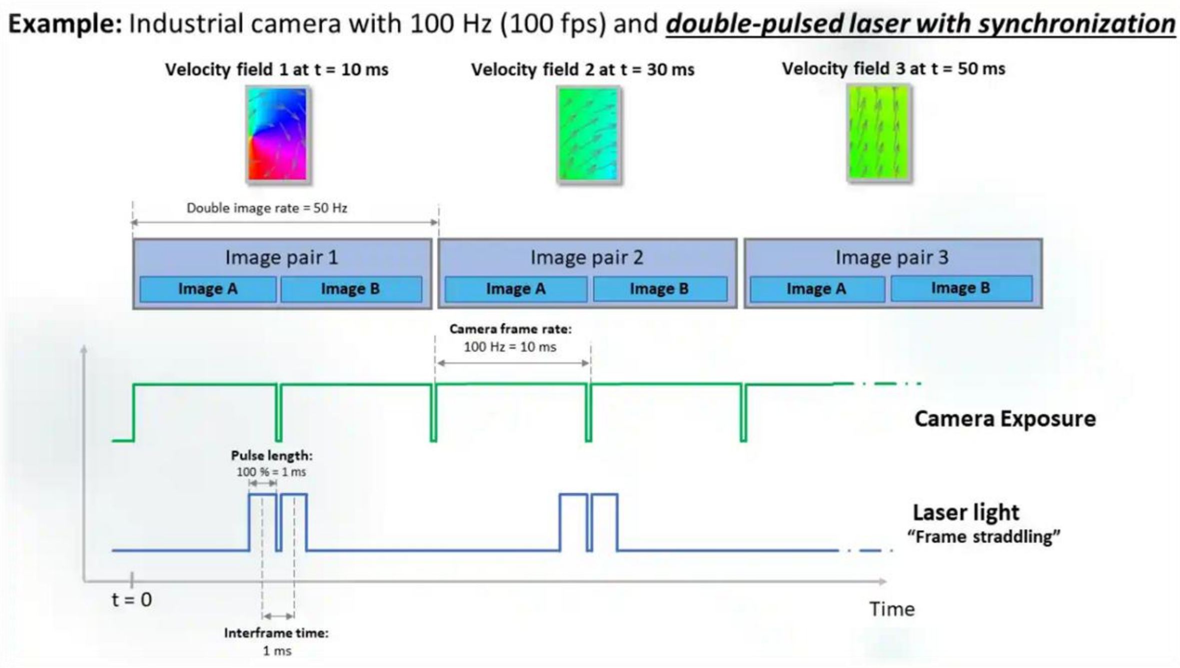

Figure 3: The principle of frame-straddling, lowering interframe time substantially. This is achieved by emitting the first laser pulse at the very end of the first image exposure, and the second pulse at the very beginning of the second image exposure.

The synchronizer can be attached to our laser modules, which reduces the complexity of the PIV setup. Suitable parameters like pulse length, interframe time, frame rate etc. are calculated and transferred wirelessly from PIVlab. This means that only one cable is required for the connection to the camera trigger input.

Figure 4: Left: The synchronizer can be attached to all laser modules. Right: PIVlab can control the timing of the synchronizer.

The synchronizer can additionally be used as a stand-alone device (Synchronizer Dock required). When clicked into the Synchronizer Dock, four additional outputs are available, e.g. for using the synchronizer with Q-switched dual head lasers.

Figure 5: When the synchronizer is used as stand-alone device, it is attached to the Synchronizer Dock.

CAMERAS

When using a camera supported by PIVlab, the PIV experiment becomes very easy: All internal camera timings (delays, maximum exposure, supported frame rates, etc.) are stored in PIVlab, the user only needs to set three numbers (frame rate, interframe time and laser energy). With the click of a button, the camera and synchronizer are started using frame-straddling with appropriate timing, the images are saved and ready for analysis in PIVlab. See a complete list of the supported cameras (from low-cost to high-end) here:

https://optolution.com/en/products/particle-image-velocimetry-piv/cameras-overview/

OTHER DEVICES

There are additional devices available for the OPTOLUTION PIV system: Most of them can be controlled wirelessly from PIVlab, including remote lens controls, laser warning signs, seeding generators, micro-PIV devices, educational water tunnels etc. Check our website to learn more:

https://optolution.com/en/products/particle-image-velocimetry-piv/

Figure 6: The OPTOLUTION PIV system consists of several optional devices.

HARDWARE SETUP & MANUAL

LASER MODULES

- To operate the modules, the power connector has to be fully plugged in (on 20 w and 40 W version, the power plug needs to be additionally secured by the screw connection).
- The key has to be inserted and turned clockwise to power the laser (and any attached devices) on. The green LED on the laser and the cooling fan turn on.
- When the interlock connection is not closed, the laser diode is physically disconnected from the power supply and cannot turn on.
- Connect the interlock cable to a suitable mechanical switch (normally open, e.g. door switch).

WARNING: When the two wires from the interlock cable are connected, then the laser is ready to emit light. ALWAYS wear safety glasses! ALWAYS make sure that the laser light hits a suitable beam dump (e.g. a thick matte black metallic object).

- If the interlock is closed, the yellow LED will turn on, indicating that the laser is ready to emit light.

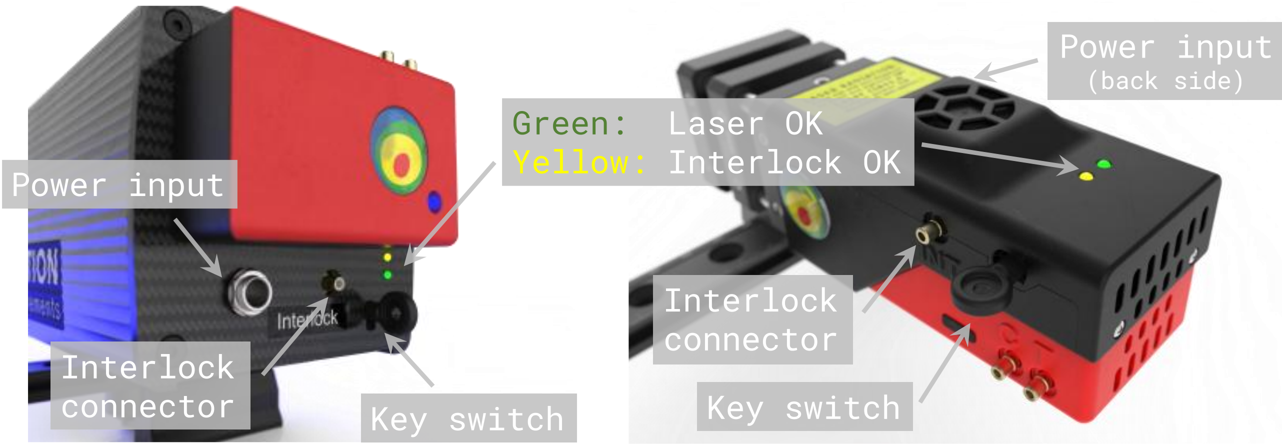

Figure 7: Connectors and LEDs on the 20 and 40 W system (left), and the 0.5 and 5 W system (right)

The cable ends of the interlock should be connected to a proper door switch (normally open). When someone opens the door (switch opens), the laser will turn off immediately.

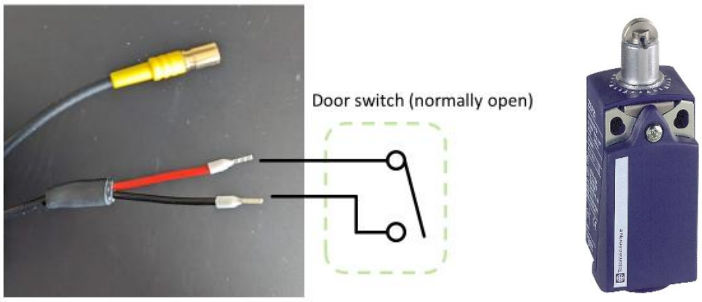

Figure 8: Left: The mandatory interlock connector. Right: The open cable ends can be connected to a door switch, e.g. XCKP2102P16.

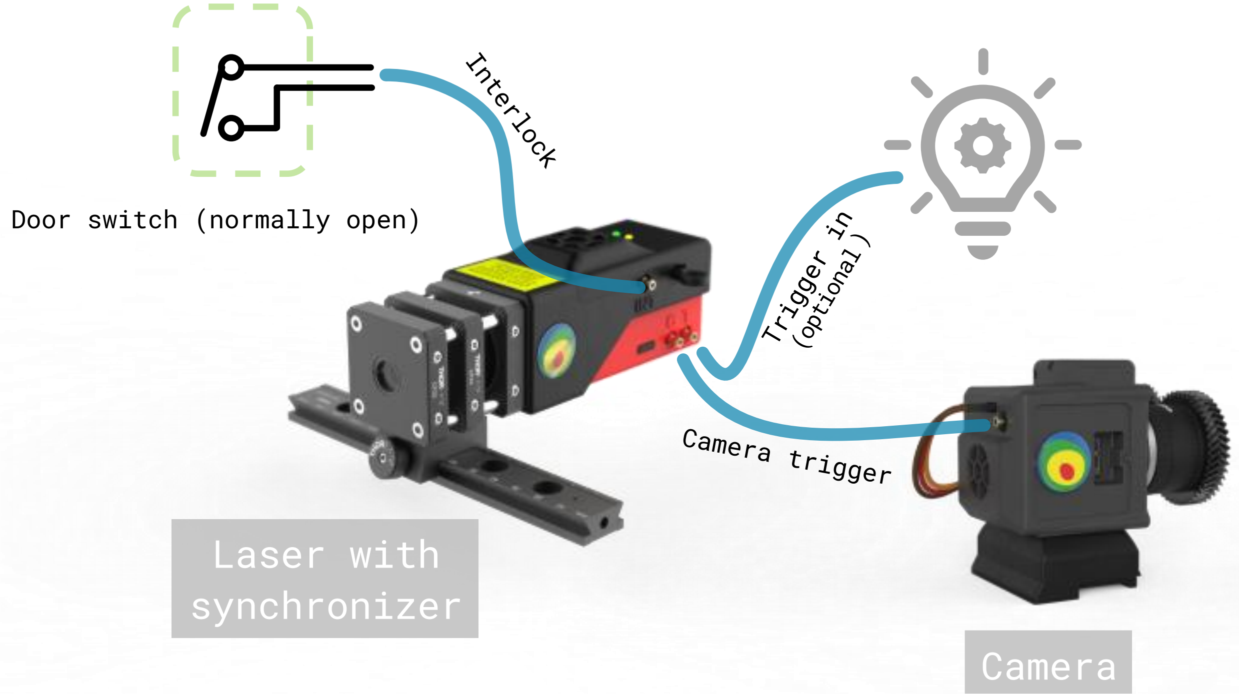

Figure 9: Cable setup when using the OPTOLUTION synchronizer, plugged directly into the laser module.

Laser module usage with third party synchronizers

If the laser modules are not used with our synchronizer, but should instead be triggered by third-party synchronizers or devices, please follow these instructions:

- You need to use the Connector Breakout to connect external devices. The red LED on the Connector Breakout indicates the current input status (LED on = high signal on input, LED off = low signal on input).
- A voltage between 3.0 V (minimum) and 5.0 V (maximum) applied to the “T” (trigger) input will enable light emission.
- A voltage between 0.0 V (minimum) and 1.0 V (maximum) applied to the synchronizer input will disable light emission.
- Do not supply voltages below 0 V or above 5 V to the synchronizer input!
- Maximum toggle frequency is 500 kHz
- The lasers thermal setup is designed to operate at a maximum duty cycle of 50%. Otherwise, the thermal protection of the laser driver will kick in and temporarily disable laser output (green LED on the laser module will start blinking). The maximum pulse length is 10 ms. It is the user’s responsibility to follow these limitations. Operating the laser at higher duty cycles will reduce the life time of the laser diode.

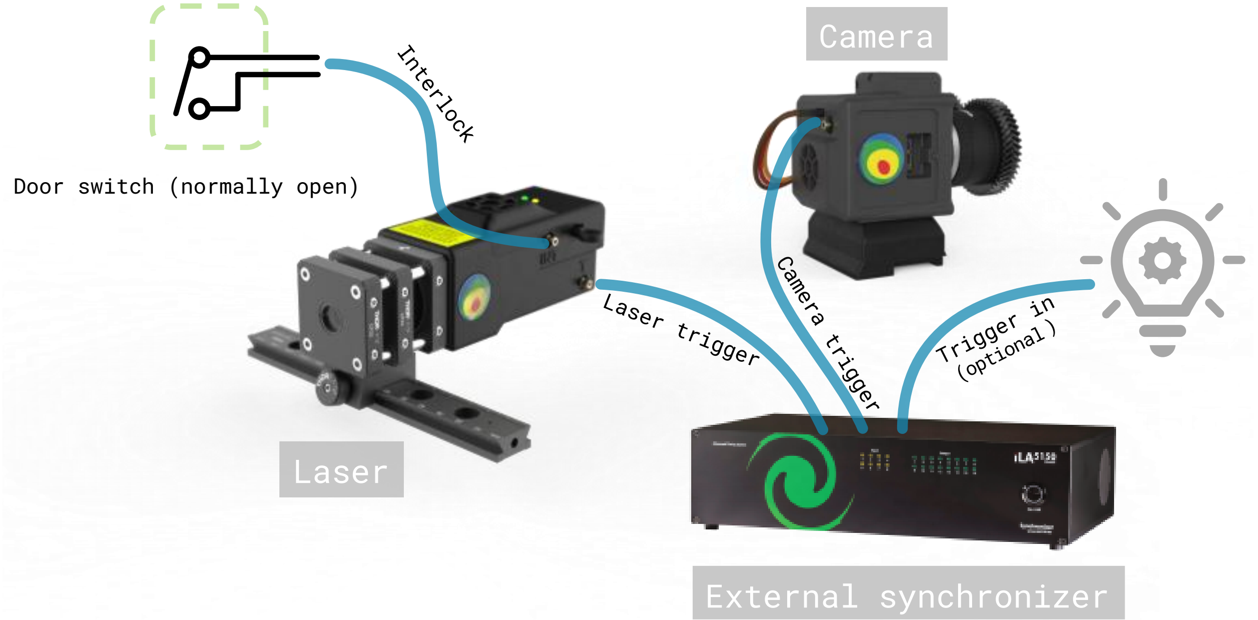

Figure 10: Cable setup when using an external synchronizer. The laser is equipped with the Connector Breakout.

OPTOLUTION

Sheet optics

The laser sheet optics are an integral part of our laser modules and cannot be removed. The sheet focus can be set by moving the central lens holder. Keep the optics free from dust, otherwise the lenses might be damaged.

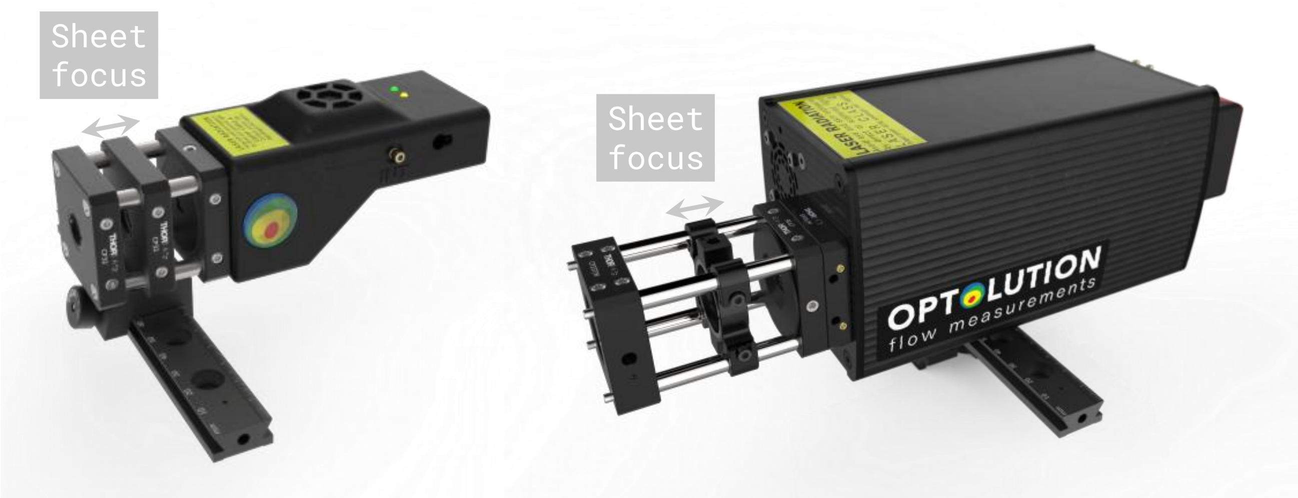

Figure 11: Adjusting the focus of the laser sheet for the different laser modules.

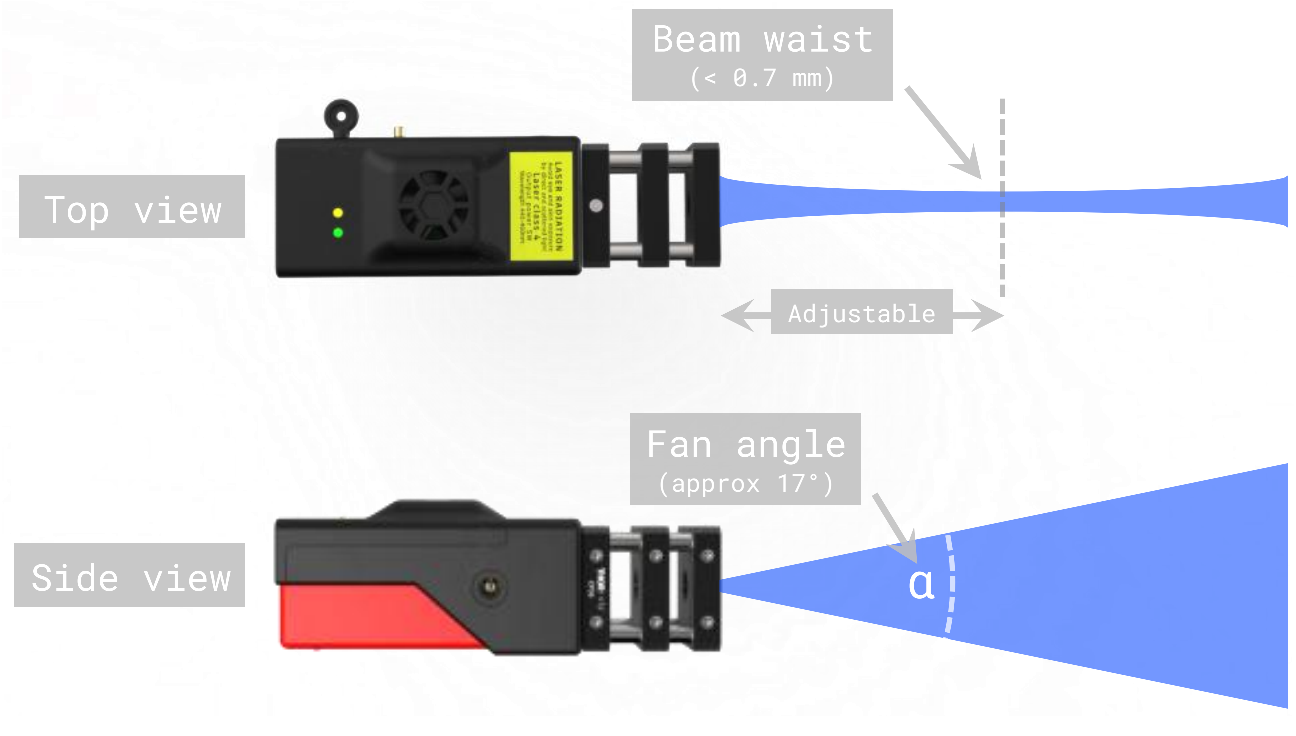

Figure 12: Moving the sheet focus lens sets the position of the beam waist and the sheet thickness in the region of interest.

OPTOLUTION

SYNCHRONIZER

PIV experiments should be as simple as possible; therefore, the synchronizer can be plugged directly into our laser modules. It is powered by the laser module, and receives commands and settings wirelessly. In this configuration, the synchronizer synchronizes the camera and the laser pulses, and can react to external signals on the trigger input connector. All the timing parameters are calculated automatically in PIVlab for the supported camera models. Connect the trigger input (sometimes called "sync-in") of the camera to the output marked "C" on the synchronizer (LVTTL). When using external triggers to control the PIV experiment (optional), these need to be connected to the "T" input on the synchronizer (TTL, see Figure 9).

The synchronizer can also be used for other applications. In this case, it needs to be connected to the Synchronizer Dock (see Figure 5). The docking station will provide power to the synchronizer and gives access to four additional outputs (five outputs in total, one input). When not used with PIVlab and our laser diodes, a windows software is supplied (OLTsync), that allows flexible configuration of all output channels.

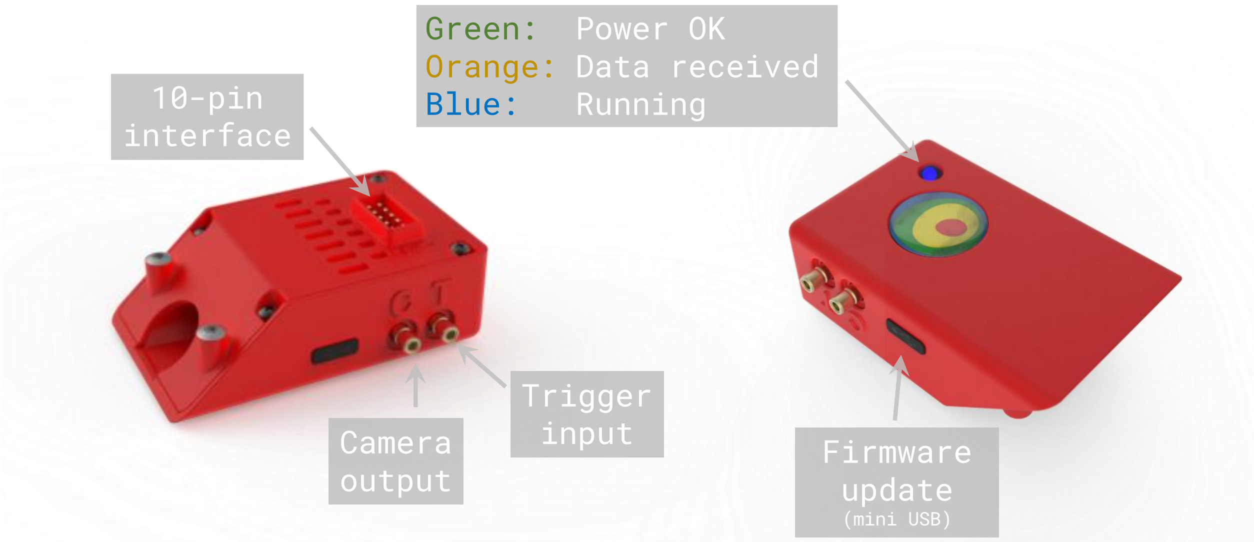

Figure 13: Connectors and LEDs on the synchronizer.

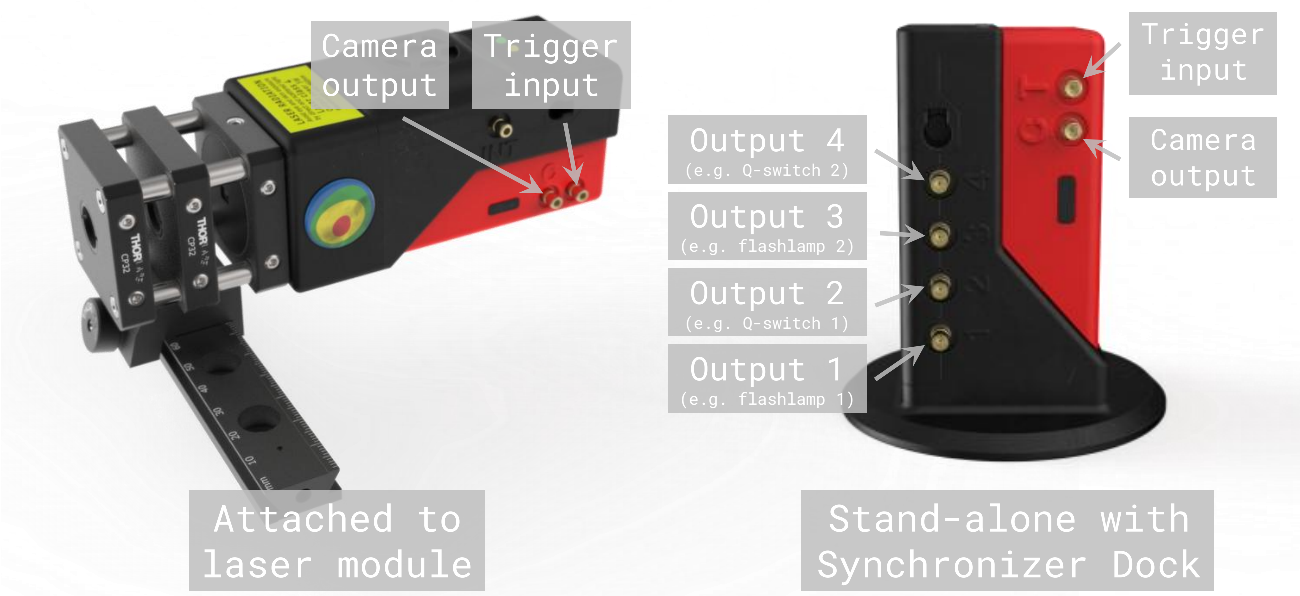

Figure 14: Left: Synchronizer plugged into the 5 W module. Right: Synchronizer plugged into the Synchronizer Dock.

The communication between the computer and the synchronizer in the device is implemented with a wireless serial link. The white/green USB dongle must be inserted, and the driver ("CP210x Universal Windows Driver", supplied on an USB stick) must be installed. Check windows device manager to see if the dongle was installed properly (and note the COM port number in case you have several).

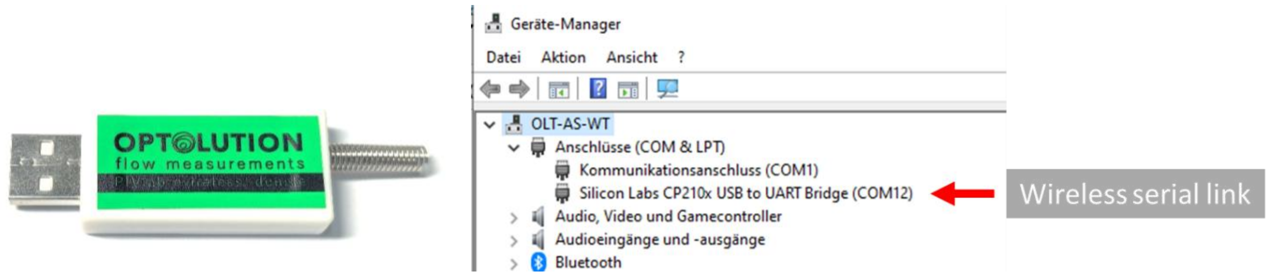

Figure 15: Left: The wireless USB dongle. Right: Verification of driver installation in Windows device manager.

Connect to this COM port in PIVlab or OLTsync to change timing, trigger types and start or stop the device.

Synchronizer plugged into a laser module (control via PIVlab)

- Select a suitable configuration ("PIVlab LD-PS" + your camera model), select the correct COM port for the wireless USB dongle and hit connect.
- When you connect for the first time to your laser, a message box will appear, asking you to insert the ID of the laser. This ID is detected automatically, and can additionally be found on a small sticker on your synchronizer.
- The LED on the synchronizer should briefly flash orange to indicate that data was exchanged with PIVlab. The laser status should change to "Laser OFF".
- Set the frame rate to a low value (e.g. 5 Hz), the pulse distance (interframe time) to 1000 µs, and the laser energy (pulse length) to 10%.
- Place a suitable beam dump in front of the laser, close the interlock and start the laser by clicking "Toggle Laser". The laser status should change to "Laser ON".
- Click the toggle button again to turn off the laser.

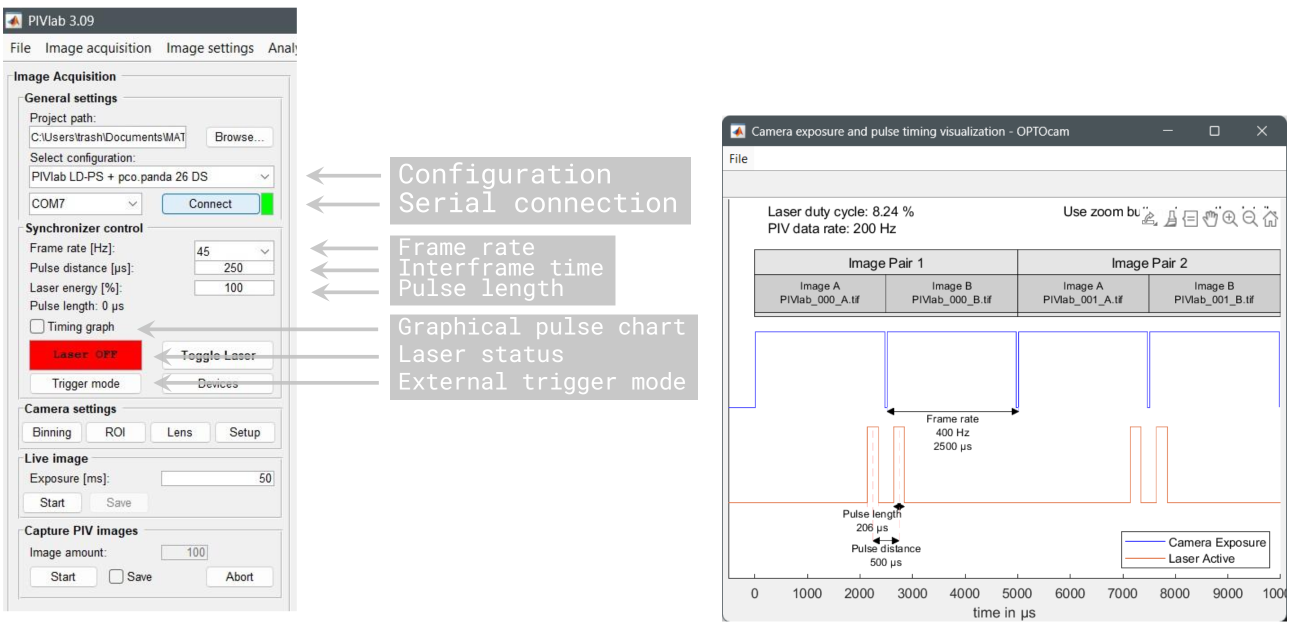

Figure 16: Left: The synchronizer interface in PIVlab. Right: PIVlab shows a visualization of the pulse timings.

"Frame rate", "pulse distance" and "laser energy" are important parameters for frame-straddling, and defined in the following figure:

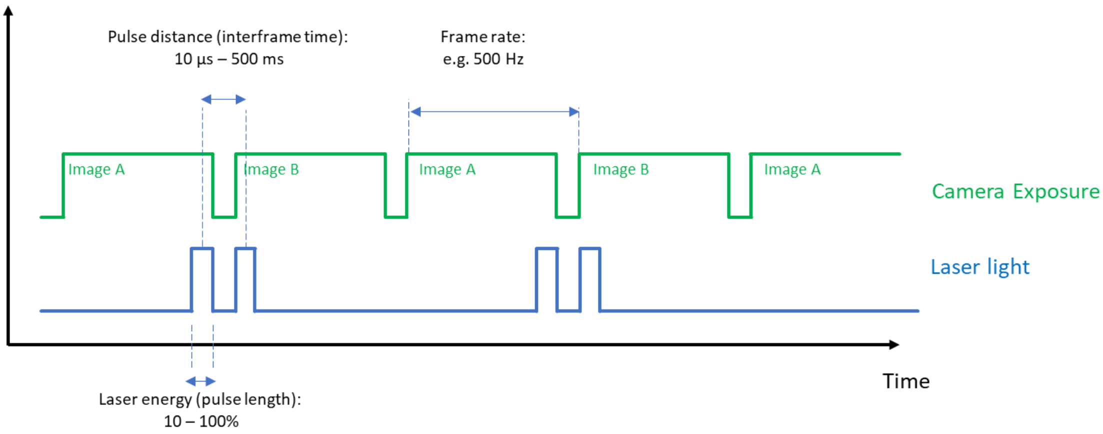

Figure 17: Definition of "Frame rate", "pulse distance" and "laser energy".

The setting for "laser energy" defines the pulse length. A setting of 100% means that the pulse length has approximately the same length as the pulse distance. The exact pulse length depends on a number of parameters; therefore, it is shown in the PIVlab GUI after the laser has been turned on. A higher laser energy makes the particle images brighter, but it will also increase the motion blur.

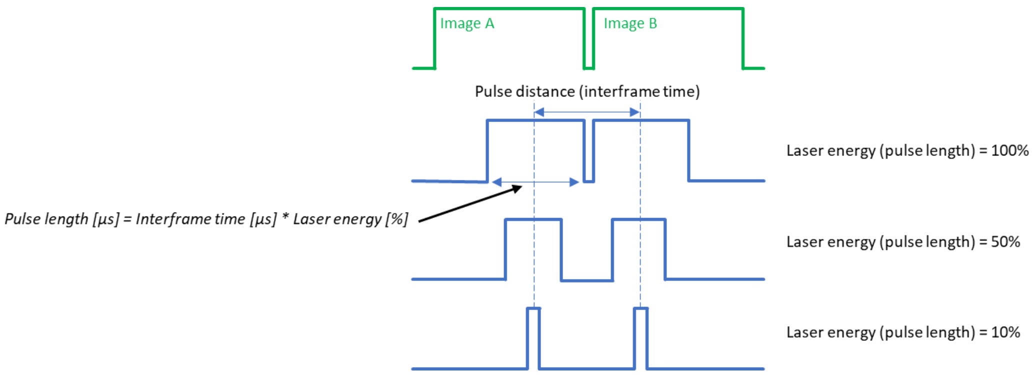

Figure 18:Details on the relation of laser energy and pulse length.

Using the synchronizer without PIVlab

The synchronizer can be operated without PIVlab using the software oltSync. When used together with the Synchronizer Dock, five channels can be configured. When used without the dock, and plugged into one of the laser or LED modules, two channels can be configured (channel “C” for the camera, and channel “1” for the laser / LED module). Presets can be stored and loaded, and the trigger input can be configured.

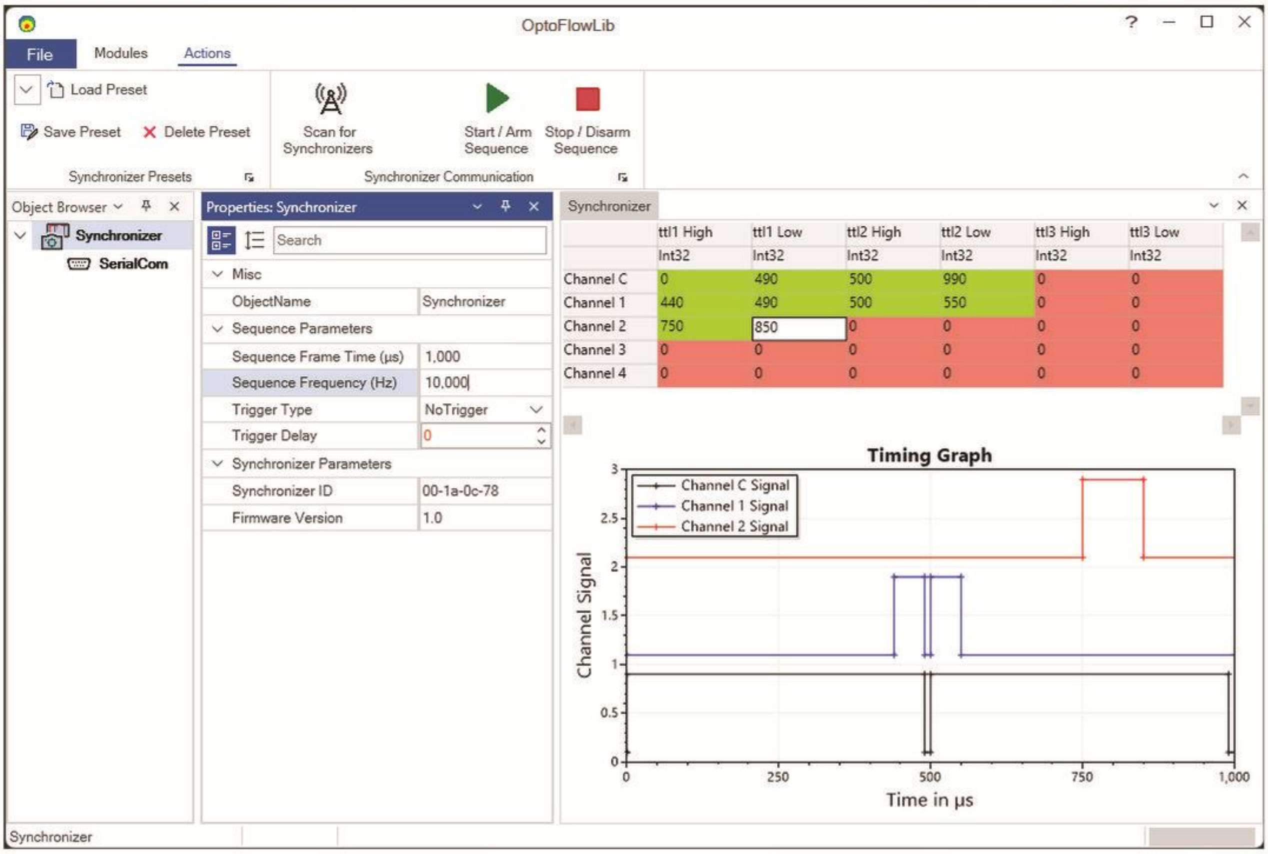

Figure 19: Screenshot of the oltSync software. This software can be used to configure the synchronizer for use with any laser or camera, and without PIVlab. The timing sequence for all five channels can be set as needed.

Trigger modes

The synchronizer can react to external events. Currently, four modes are implemented:

- Mode 0: Internal. Uses the configured camera and pulse timings, and starts recording when 'Start' button is clicked, stops when ''image amount'' is reached.
- Mode 1: External – Double shot on rising edge. Uses the configured camera and pulse timings, arms when 'Start' button is clicked, records one double image each time trigger goes high, stops when 'image amount' is reached.
- Mode 2: External – Shoot while high. Uses the configured camera and pulse timings, arms when 'Start' button is clicked, records while the trigger input is high (and pauses when it is low), stops when 'image amount' is reached.
- Mode 3: External – Start on rising edge. Uses the configured camera and pulse timings, arms when 'Start' button is clicked, starts record when the trigger input goes high, stops when 'image amount' is reached.