



Service of Ultrafast Optical Spectroscopy USER GUIDE

Rev. 2.0 - 26/01/2022

Introduction

This guide provides basic useful informations to users with a self-service authorization to the CeSAR Laboratory of Ultrafast Optical Spectroscopy. Users with full-service authorization are also invited to read this guide as they will find useful informations.

This guide is not intended as an extended course or training in lasers and optical spectroscopy.

The Service of Ultrafast Optical Spectroscopy laboratory is located at CeSAR ground floor, room CS10. The lab specialist is Dr. Marco Marceddu (mail: marco.marceddu@unica.it /phone +390706756584/ ground floor, room CS3).

The first step to access CeSAR services is to apply for a specific authorisation. Access levels to the lab are authorized by CeSAR Director. Two access levels are available: full service and self service. Self service is reserved only to UniCa staff users, with certified expertise in ultrafast lasers and optical measurement systems. Expert users not familiar with our specific lasers and instruments (brand/model), will receive familiarization training on demand.

Full service is devoted to third party users and UniCA users with no specific expertise. In this case measurements will be performed by the lab specialist.

Once you get your access level you can schedule and book lab-time by e-mail to the lab specialist. In case of priority activity or extraordinary maintenance, the staff may change your booking.

Ordinary opening hours are 8:00 am–5:30 pm, Mon-Fri.

Special needs must be authorized by the CeSAR Director. Each lab session must be recorded in the lab register.

When you leave the lab and the end of your day, or have to leave the lab for some minutes, always inform the lab specialist or other CeSAR personnel. **We need to know who is in the building and, in particular, do not leave running lasers unattended.**

The lab employs class 4 lasers, with potentially dangerous UV-VIS-NIR radiation. Refer to section 1 for a short review of laser safety guidelines.



The standard optical layouts of both time resolved fluorescence and pump-probe absorption experiments are intended for general purposes. **Changes of this standard configuration are not allowed.** Specifically tailored configurations must be previously authorized by the lab specialist.

Experiments involving instruments or components from other UniCa Departments must be authorized.

Users are not allowed to open laser covers, adjust internal laser optics, change computer settings nor to plug external memories or other devices to lab computers. Data transfer will be performed by CeSAR staff.

Any failure and anomaly must be immediately communicated to the lab specialist.

It is recommended not to listen to music nor use earphone: noises are often good indicators of something going wrong.

The lab employs UPS systems. In case of black out UPS will supply power to the lab and beep-sound alarm will be emitted. UPS are intended to protect instruments and lasers from voltage/current spikes and to ensure the completeness of the systems shutdown in case of emergency. Indeed, the lab lasers employed particular crystals that are kept at 160 °C. In case of black out these crystals must thermalise slowly at room temperature in order to prevent damages. Therefore, UPS are not intended to continue the experiments for hours in case of back out. **In case of prolonged main power failure (say 5 min.), immediately stop the experiment and call the lab specialist who will start the shutdown procedures if needed.**

As a general rule of the lab: if some procedure is not clear, if you don't feel fine in performing allowed alignment operations, even if you're scared by laser power, if you notice something strange in the lab (noises, smells...), always refer to the lab specialist. Do not worry about disturbing or boring: this is his job.

1. Laser safety guidelines

General Informations

This section provides safety informations for working in room CS10. You will also find synthetic advices in the lab.

The laser employed in the lab are class 4 classified. This means that visible and invisible radiation extremely dangerous is present, even if reflected or scattered. Lasers employ high voltage power supplies and water cooling systems: pay attention to noises, smells and water fugues. In any case **if you notice anything strange or out of your ordinary experience, immediately call the lab specialist.**

The lab has three different lasers sources: Libra, Topas and Chameleon.

Libra is a titanium-sapphire regenerative amplifier (emission 800 nm, 1 KHz repetition rate, 4.5 W mean power). Topas is an optical parametric amplifier (OPA – emission 350-1200 nm, rep rate 1 KHz, power up to 500 mW depending on wavelength). Chameleon is a titanium sapphire tunable oscillator (emission 650-1010 nm, rep rate 80 MHz, max mean power at 800 nm 4.3 W), equipped with a frequency doubler device that further extend the Chameleon emission down to the blue. All these lasers may cause severe injuries to skin and eyes and damage or burn objects. **In particular**

when working with Chameleon be extremally carefull: due to its high repeton rate and tiny spot dimensions, tissues, dresses, allingnment cards or other objects can easily burn. This may holds also for Libra and Topas, when the beams are focused in small spots.

Safety Rules

The following *golden* rules must be always strictly observed:

1. The laser lab is a restricted acces room: only authorized personnel
2. When lasers are running the red lighth bulb on the entrance doors must be kept on
3. Evoid skin and eye exposure to direct or scattered laser lighth
4. Wear laser protective eyewear
5. In order to avoid uncrontrrolled laser reflections take off watches and reflective jewelry
6. Long hairs must be tied and loose clothing must be secured
7. Always be aware of laser beam path
8. Never look at laser beam path eighth (namely within 15-20 cm from table top)
9. Unused laser beam path-arms must be secured with black panels (low power beam) or beam stop (high power)
10. Avoid uncontrolled reflection from filters, neutral densities or mountings; use black panels.

PPE – Personal Protective Equipment

When working with laser in lab CS10, you must always wear laser safety spectacles. Two different types of laser protective spectacles are available for specific pourposes: memorize the difference and be very carefull when choosing the proper glasses.

The first spectacles are shown in figure 1(for simplicity called *White Mask*). These spectacles offer the best protection at 490-550 nm (OD>8), **but does not protect your eyes at all for wavelength larger than 600 nm**. White Mask must be used when working with Evolution green laser (only authorized personnel) and are suitable also for short-wavelength radiation of moderate intensity. The optical density vs wavelength curve is shown in figure 1.

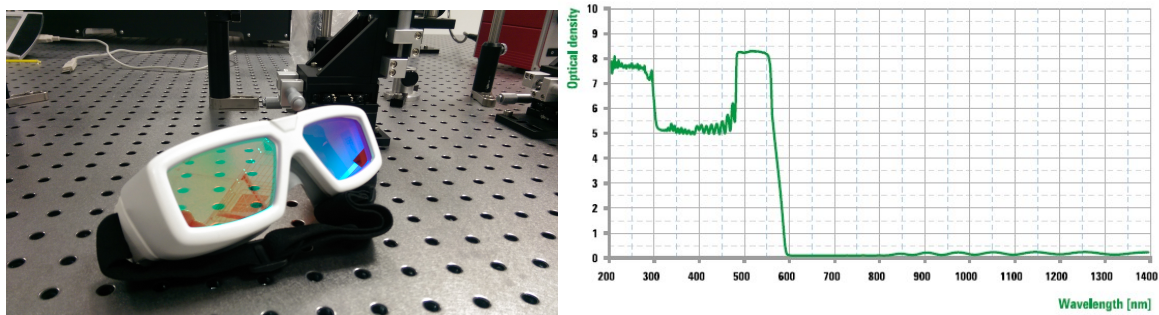


Figure 1: White Mask spectacles are suitable for UV-GREEN high intensity laser radiation (left: the spectacles; righth: OD attenuation curve)

The second spectacles (for simplicity here called *Star Trek*, see figure 2) uses general purposes, broad band, medium attenuation filters. Star Trek are suitable for the fundamental emissions of both Libra and Chameleon (OD>8 at 800 nm) and for TOPAS UV-BLUE and RED-NIR emissions. **Pay attention: Star Trek offers only moderate protection in the green; for high power green beam White Mask is the best solution.**

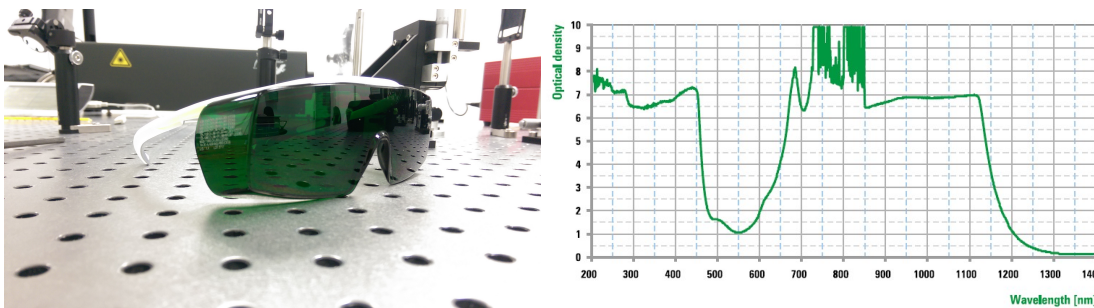


Figura 2: Star Trek spectacles are suitable for UV-NIR laser radiation (left: the spectacles; right: OD attenuation curve)

2. The lab rules

General Informations

Being a service facility available to different users, the lab is organised with a general purposes layout. For the same reason **some basic rules must be observed**. Please always remember that you are in a multi-users laboratory, not in your own lab. Please observe the lab rules and leave the lab neat and tidy as you found it. Avoid the rat-pack mentality: hurry, disorder, drab, inaccuracy are our worst enemy. We will very appreciate your collaboration to make the lab a nice and reliable workplace for as many users as possible, but always remember that in case of problems, **the staff is authorized to deny further acces to the lab** (see CeSAR general regulation).

In the lab foods and drinks are not allowed: you'll find a comfortable resting room at 1st floor, room CR32.

For safety reason always wear appropriate dresses: no open shoes and shorts are allowed in the lab; long hairs must be tied and loose clothing must be secured.

When lasers are running always keep in mind the 10 goldens rules (see previous section).

Any failure and anomaly must be immediatly communicated to the lab specialist.

It is raccomened not to listen to music nor use headphones: noises often are good indicators of something going wrong.



Mechanical tools, optical accessories, manuals and so on are available in the lab cabinets: feel free to use what you need, **but at the end of the day keep everything in place**. In particular filter and other optics must be placed in their storage boxes. If, for any reason, you need to leave the lab for sometimes (coffee break, courses, exams, seminars...): **place beam stop at laser main exit, cover the spectrograph entrance slit, close streak camera shutter and set mcp gain to zero, inform the lab specialist**.

As a general rule of the lab: if some procedure is not clear, if you don't feel fine in performing allowed alignment operations, even if you're scared by laser power, if you notice something strange in the lab (noises, smells...), always refer to the lab specialist. Do not worry about disturbing or boring: this is his job.

Experiment Configuration

The standard optical layouts of both time resolved fluorescence and pump-probe absorption experiments are intended for general purposes. This standard layout may not meet the specific requirements of particular experiments, but please keep in mind that **changes of the standard configuration are not allowed**. Specifically tailored configurations must be previously authorized by the lab specialist. In this case also consider to schedule and book several consecutive days. Experiments involving instruments or components from other UniCa Departments must be authorized.

Computers

In order to maximize the stability of lab computers and prevent damages from viruses and malwares, **users are not allowed to: change PC settings, install programs, plug personal memories or other external devices**. Your experiment data will be transferred by the CeSAR staff.

If for any reason you need some specific software, do not install it by yourself; always ask to the lab specialist.

Air conditioning

The lab temperature is kept at 24°C to optimise laser performances: don't change this value for any reason and keep the doors closed.

Electric power plant

The lab has two electric power plants. With minor exceptions (see section 3), **you are not allowed to open and operate on the electrical cabinets**.

The first power plant is for general purposes and is controlled by electrical cabinet n° 8. It is devoted to lightning, ordinary socket (located on the walls at 1.2 m from floor) and other technical facilities (water, ventilation, laser advise sign). Feel free to use this section to plug your laptop or other minor devices. **The second one is reserved to lasers and measurements instruments**. This section is controlled by the electrical cabinet with the plastic green transparent cover and supplies power to the industrial-type sockets on the walls, and to the normal sockets located on the roof-shelter. Industrial-type sockets are reserved to lasers, chillers and measurements systems. They employ two UPS with power loads distributed as follows: chillers alone on UPS n° 2 (to prevent

earth-loops); lasers, Streak camera, Helios and lab computers on UPS n°1. **Do not change loads distribution.**

In case of black out UPS will supply power to the lab and beep-sound alarm will be emitted. UPS are intended to protect instruments and lasers from voltage/current spikes and to ensure the completeness of the systems shutdown in case of emergency. The lab lasers employed particular crystals that are kept at 160 °C. In case of black out these crystals must thermalise slowly at room temperature in order to prevent damages. Therefore UPS are not intended to continue the experiments for hours in case of back out.

In case of prolonged main power failure (say 5 min.), save UPS battery charge. Immediately stop the experiment and call the lab specialist who will decide to shutdown the lab if needed.

Special purposes electronics should be plugged to roof shelter sockets, but it is important to avoid phases unbalance: please ask to the lab specialist.



Figura 3: power plant reserved to lasers and instruments. From left to right: electrical cabinet, industrial-type socket, roof shelter sockets.

Technical facilities

The lab is equipped with a closed cycle water-cooling plant. The main valve is located in the gray electrical cabinet (cabinet n° 8), while several secondary valves are located along the room perimeter. This plant is intended as a ballast tool in case of laser chiller fault, or for special experiments. Users interested will be trained on demand. The lab is also equipped with a gas delivery pipe plant (He, N₂, O₂, CO₂, compressed air, vacuum): please ask for specific authorisation and training. **The usage of water-cooling and gas plants is forbidden to unauthorized personnels.**

3. Lasers procedures

When working with class 4 lasers specific light sign located on the entrance door are mandatory. **This light must always be ON when lasers are running.** Remember to turn off this light, when you turn off the lasers. The “laser on lamp” switch is located in the upper section of electrical cabinet n° 8 (see figure 4). **This is the only switch you are allowed to touch in the electrical cabinets.**

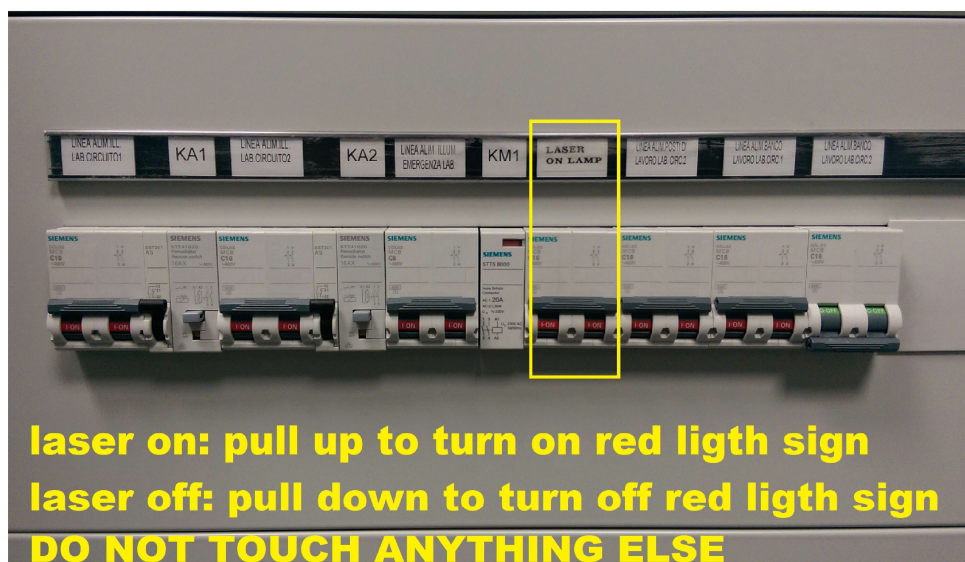


Figura 4: laser running red light sign

The lab lasers have two different start up and shut down procedures, named long term and short terms. Typically you will not be asked to perform long term procedures. In the following you will find

detailed descriptions of short term procedures, usefull for daily operation. Copy of these checklists are available in the lab nearby the lasers.

3.1 Power Meter


The lab optical power meter comes with three different heads: memorize the difference and always employ the best suited one. **The main beam from both Libra and Chameleon must be measured only with the massive head with cooling feens** (see. Figure 5) since it has the largest damage threshold. It can also be employed with most intense TOPAS wavelentghs. The second one is a silicon photodiode (PD300-1W, see figure) with a removable attenuation filter. With filter out the working range is 350-1100 nm / 500 pW -30 mW, while with filter in working range is 430-1100 nm / 200 μ W -1 W The last one is an UV-enhance silicon photodiode (PD300R-UV, see fig. 5) with removable attenuation filter. With filter in the working range is 220-1100 nm / 2 μ W – 300mW, while with filter out the working range is 200-1100 nm / 200 μ W-3W. **Never use the silicon photodiodes to measure Libra and Chameleon main output: they will be destroyed; pay attention also with certain TOPAS wavelentghs** (see TOPAS tuning curves). Silicon photodiode can be safely employed only with attenuated radiations.





Figura 5: power meter heads. From left to right: high power head for Libra and Chameleon; Silicon Photodiode; UV-enhanced Silicon photodiode


3.2 Libra Procedures

Always compile the Libra Logbook and measure the laser power at start, at regime and at the end of your session. **Your are not allowed to change the laser settings** (diode currents, LBO temperature, Pockels cell timing and so on) **nor to perform internal optics alignment**. These issues are reserved only to the lab specialist. If you notice power decrease or instability, poor mode quality, bad pulse build-up on the oscilloscope, or anything else strange, **immediatly call the lab specialist**. Rember that Libra output is splitted in 3 different arms: one is used to pump Topas, one to generate the probe beam in the Helios spectrometer, and one eventually to generate the second harmonics. **Always block unused arms with proper schilds**.

**START UP****TURN ON “LASER ON” WARNING LIGHT** **PLACE POWER METER HEAD OR PROPER BEAM STOP IN FRONT OF LIBRA**
EXIT 

1. **Chiller:** 
 - a. check fluid level
 - b. check that is operating at 24 °C
2. **Vitesse laser** (Ti:Saff oscillator seed)
 - a. turn key to ON
 - b. wait 2 min
 - c. open shutter
3. **Evolution laser** (Nd:YLF – amplifier pump)
 - a. Flick switch to ON
 - b. Turn key to ON
4. **Evolution Software** (on Dell laptop)
 - a. Press RUN until it beeps
5. **SDG Elite** (amplifier Pockels cell controller)
 - a. Reset Error
 - b. Enable Pockels cells: 3, 2, 1 IN ORDER 

SHOTDOWN**PLACE POWER METER HEAD OR PROPER BEAM STOP IN FRONT OF LIBRA**
EXIT 

1. **SDG Elite:**
 - a. Disable Pockels cells: 1, 2, 3 IN ORDER 
2. **Evolution software**
 - a. Press STOP
 - b. verify that diode currents goes to zero
 - c. press exit, close the app
3. **Evolution laser**
 - a. Turn key to OFF
 - b. Flick switch to OFF
4. **Vitesse laser**
 - a. Close shutter
 - b. Turn key to stand-by

TURN OFF “LASER ON” WARNING LIGHT

3.3 Topas Procedures

Topas is the lab optical parametric amplifier pumped by the Libra output. Only few percent of Libra out is delivered into Topas by means of a beam splitter, a mirror telescope and a diverter mirror (see figure 6). **During day to day operation it could be necessary to perform fine adjustment of input optics.** Specific training will be given on demand, but **if for any reason you will not feel fine with this, even if you have been trained, always call the lab specialist.**

To avoid optics damages: Topas must always work with the first entrance iris fully opened; always close the shutter before change wavelength; do not touch beam splitter and telescope mirror 1 (BS1, BS2, TM1).

The first step is to turn on Libra laser and **wait untill stable output is obtained.** In case of problems call the lab specialist. Once Libra output is stable, remove the power meter head and leave the beam propagate thowards the telescope. **Block unused beam arms.** Place the power meter head in front of Topas exit. Launch Topas software on Dell laptop, open Topas shutter and check power and stability at the selected wavelength. With minor adjustment on telescope mirror 2 (TM2, see figure 6) and diverter mirror (DM), stable and full power output should be obtained, **otherwise call the lab specialist. In any case never touch the beam splitter (BS1 and BS2) and telescope mirror 1 (TS1).** Always close the Topas shutter before change the wavelength. To change the emission wavelength: close the shutter, enter the desired value in the Topas software, follow the displayed instructions to orientate the final stage non linear crystals; a filter suitable for the selected wavelength has to be mounted on 2nd crystal.

When you have finished your experiments, close Topas shutter, exit Topas software.

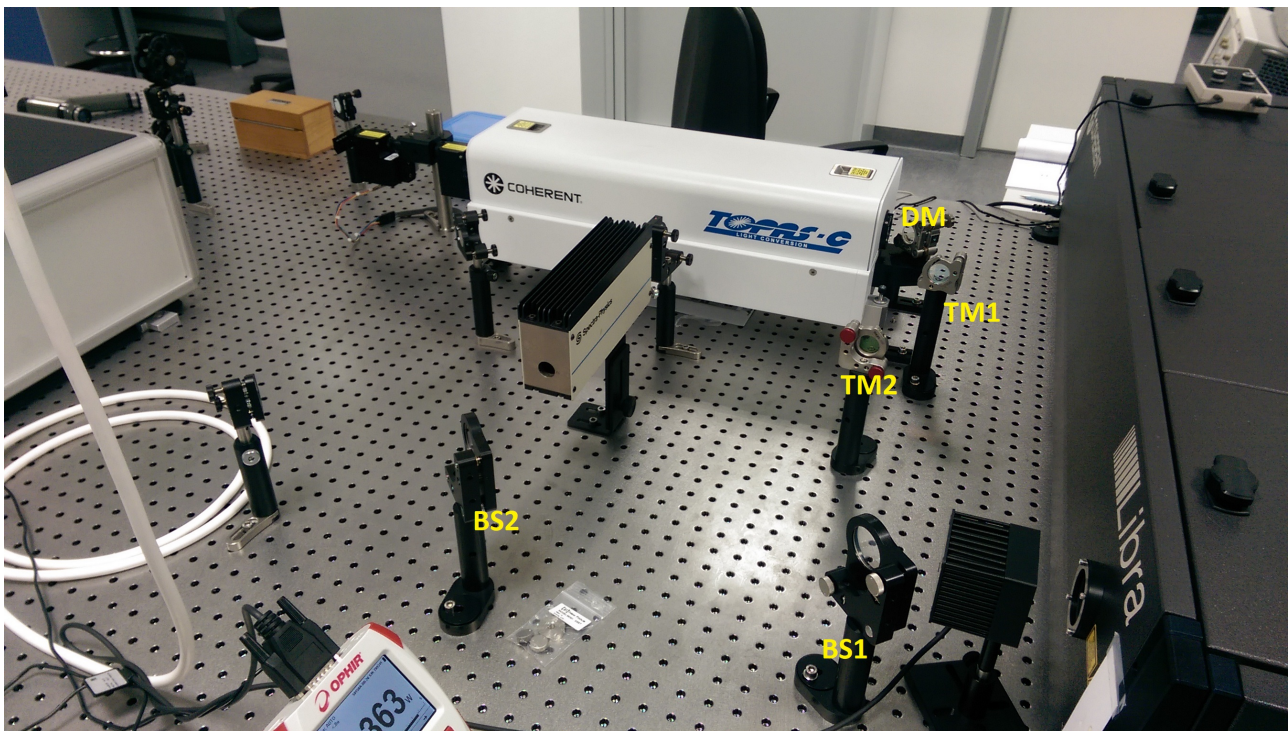


Figura 6: TOPAS input optics





3.4 Chameleon Procedures

In order to have detailed recordings of laser performances always compile the Chameleon logbook. In particular always turn on the laser at 800 nm and record power reading. If you change wavelength, record the power and, before shot down, set again 800 nm and record the power. Chameleon is a black-box-like laser and related procedures are very easy, but always comply the following steps:

START UP

TURN ON “LASER ON” WARNING LIGHT 

PLACE POWER METER HEAD OR PROPER BEAM STOP IN FRONT OF CHAMELEON EXIT 

1. Verify chiller is running at 20°C 
2. Turn key to ON
3. Wait power ramping (see laser display)
4. Open the shutter
5. to change wavelength rotate the knob until the desired value is shown on the display and press

SHOTDOWN

PLACE POWER METER HEAD OR PROPER BEAM STOP IN FRONT OF CHAMELEON EXIT 

1. set 800 nm and record the power
2. close shutter
3. Turn key OFF

TURN OFF “LASER ON” WARNING LIGHT



4. Working with streak camera

This section provides some information to prevent system damages: always comply to the following issues. This section is not intended as a streak camera training course: refer to Hamamatsu manuals. Streak camera employs multy channel plate (MCP) image intensifier, which is very sensitive and **can be easily damaged by intense light**. During signal optimisation always: **use filters or iris to attenuate/partialize light beam, start with low MCP gain values** (slowly increase during optimisation), adjust spectrograph and streak camera entrance slits.

If direct measurement of laser pulse is needed, be extremely careful: use large OD ND filters, close spectrograph and streak slits as much as possible, employ very low values of MCP gain. This may hold also for very large photoluminescence signals (ASE experiments or high yield fluorophores).

When you need a break in your experiment always: **stop acquisition, close streak shutter, set MPC gain to zero, cover spectrograph entrance slit.**

Trigger delays are stored in the streak camera software, therefore you should be able to find correct timing with minor delay adjustments. If proper timing is not achieved or you cannot find the signal, please ask to the lab specialist.

5. Working with Helios

This section provides some information to work with Helios and prevent system damages: always comply to the following issues. This section is not intended as a pump-probe training course: refer to Ultrafast Systems manuals for more details.

Day to day adjustment of optical paths both outside and inside Helios are needed: **self-service users will be trained on demand**, but few basic issues are discussed in the following. In pump-probe experiments signal stability is the most important requirement. Depending on several different parameters, obtaining the best configuration can be tricky and needs a lot of time and work: **as a self-service user, experiment optimization is your responsibility, but do not hesitate to ask the lab technician if needed.**

Remember that the Libra main beam is splitted in three different arms: one devoted to pump the TOPAS (to generate the pump), one to generate second harmonics, and one to generate the probe beam. **Never touch the first beam splitters** (2 inch of clear aperture, IR optimized optics), **you're allowed to touch just the metallic mirrors with 1 inch clear aperture** (see figure 7 –ext1-ext3).

If you need to change the wavelength range (say switch from visible to IR, or UV) the alignment procedures are slightly more complex. In particular, different white light continuum generation (WLCG) crystals have to be used: **ask to the lab specialist. WLCG crystals can be easily damaged; pay attention in changing the iris and the ND filter wheel that modulate the intensity striking on WLCG crystal. After you finished the alignment procedures, always cover the Helios: dust grains deposited on WLCG crystals can easily burn.**

In the following only visible configuration alignment will be described.

Optical layout

Figure 7 shows the Helios internal optical layout. Red lines represent IR beam used to generate probe pulse, blue lines represent pump beam and yellow lines are WLCG signal and reference path (probe). IR beam entry into Helios through first iris I1 and is launched into a multireflection delay stage; then crosses iris I3 and ND filter wheel ND1. I3 and ND1 are employed to partialize and attenuate the IR pulse in order to obtain intense and stable WLCG. From day to day the IR beam spot and intensity should be good enough to generate WLCG. **If changes are needed (I3 aperture or ND1 attenuation) be extremely careful, WLCG crystal damage may occur – if needed refer to the lab specialist.** Mirror M7 directed the IR beam on to the WLCG crystal where white light (WL) is generated. In visible configuration lens L1 is out of path (it is used for NIR WLCG). WL then crosses the sample and reaches the optical fibers (DFA1) devoted to signal detection. A portion of WL is reflected by a variable density filter beam splitter (BS1) and sent to the optical fiber devoted to collect the reference (DFA2). The pump pulse entry into Helios through I2 and I4 iris and is chopped at 500 Hz. The pump is then directed to the sample by mirror M14. ND filter wheel ND2 is used to modulate pump intensity.

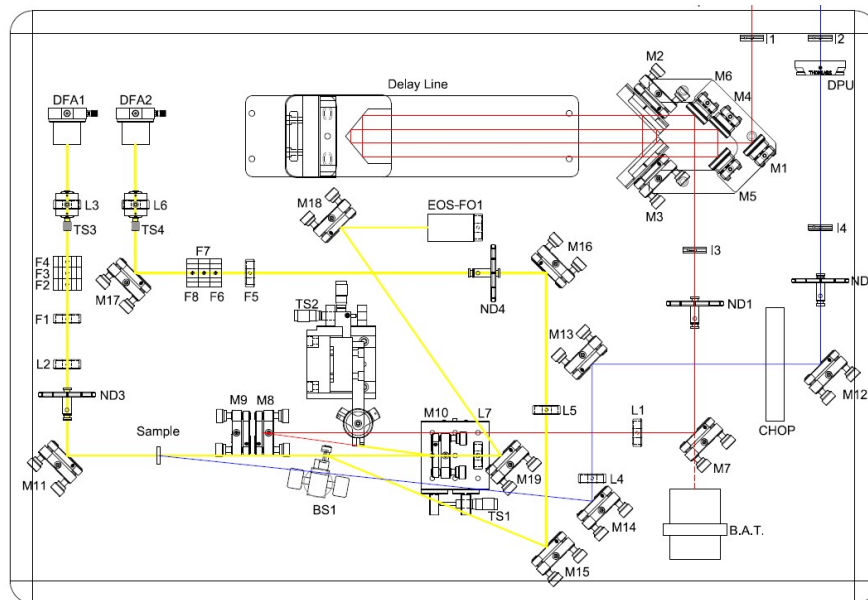


Figura 7: Helios internal optical layout

Alignment procedures

Turn on Helios cabinet and start Helios Software, select the desired configuration (UV/VIS/NIR). Remove Helios cover.

To align the probe input: center the beam into the first input Helios iris (I1 located on the Helios chassis) by adjusting mirrors ext2 and ext3 (see figure 7); the beam should propagate through the center of iris I3. Flip down mirror M7. Access *delay stage alignment* in Helios software, set “begin” and draw a circle around the spot image; move the stage to “end”. If the spot has moved, adjust mirror M1 (walking/rocking will be needed). The spot image should hold the same position while moving the delay stage back and forth. Proper delay stage alignment is one of the most critical requirements: if alignment is not correct you may face WL instabilities, in particular during long time

range scans. Flip up mirror M7 and place a white card in the sample holder: you should observe stable and intense WLCG spot. **If you notice instabilities or no WLCG at all, do not exceed with I3 and ND1: block beam at input and call the lab specialist.**

Access probe monitor on Helios software and optimize the signal collection by adjusting L3 (position and focus) and DFA1. **If the spectrum looks unstable call the lab specialist.**

Then maximize reference and signal collection by adjusting L6 (focus and position) and DFA2.

Place the sample in the sample holder and verify both signal and reference collection (minor adjustments may be needed). In order to maximize the experiment sensitivity, signal and reference should have the same amplitude in the wavelength range of interest: use BS1 to balance the two arms intensity. Block beam at input.

To align the pump: center the beam into first pump Helios iris (I2 located on the Helios chassis) by adjusting mirrors ext4 and ext5 (see figure 7-8); the beam should propagate through the center of iris I4 and optical chopper (use ND2 to attenuate or increase pump intensity). Access *Overlap Adjustment* on Helios software. **The maximum time overlap between pump and probe pulse should be at 232 ps: set longer value of the delay in order to be sure to observe pump-induced signal.** Let propagate pump and probe pulse on your sample and look for spots overlapping. Use mirror M14 to overlap the pump spot onto the probe spot (do not move the probe). Set a relative long delay and look for some positive or negative signal in the spectrum. Maximize this signal by moving mirror M14 (overlap fine adjustments). By moving the delay stage look for your experiment zero timing.

Helios alignment is completed. Put Helios cover in place (be careful) and run your experiment.

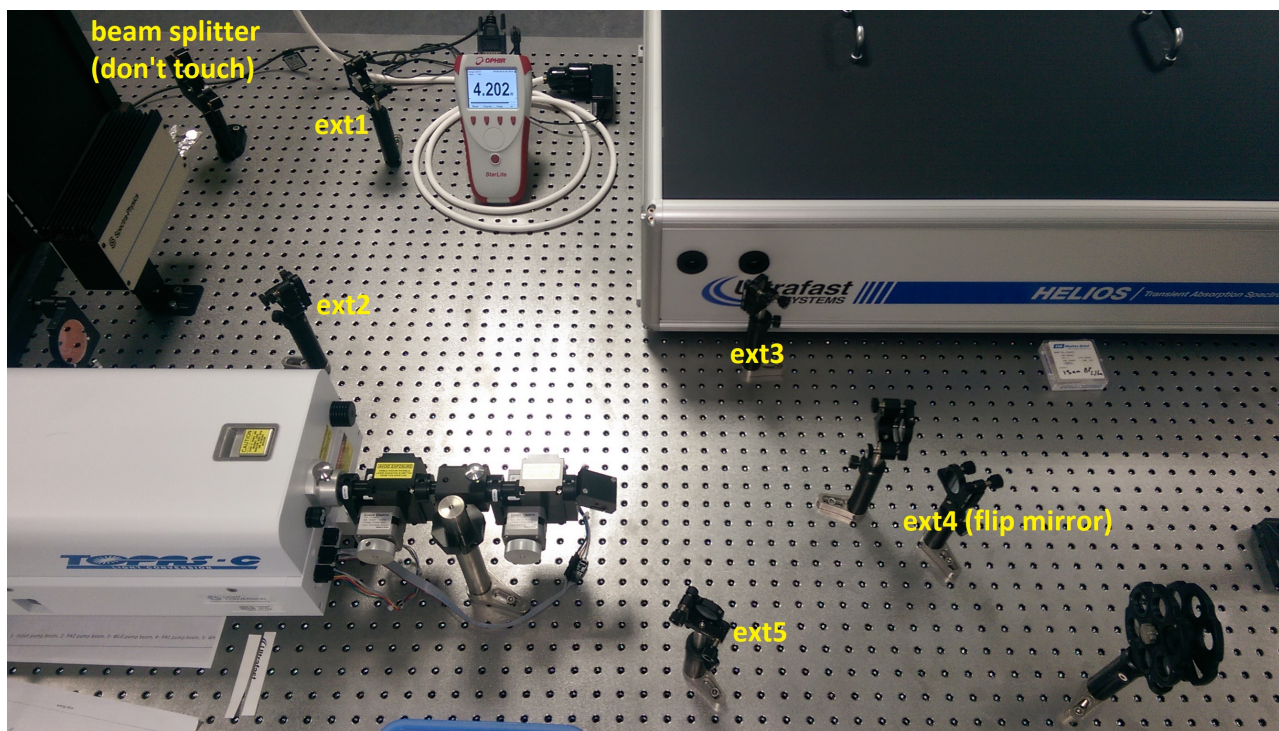


Figura 8: external input mirrors



4. In case of emergency

Please refer to the official University safety and emergency rules:

General procedures:

<https://www.unica.it/static/resources/cms/documents/37862445b945116b96dcfb7d4b864e7c.pdf>

Emergency plan:

<https://www.unica.it/static/resources/cms/documents/37862445b945116b96dcfb7d4b864e7c.pdf>

As general rule, always keep in mind that in case of emergency, people's safety comes first.