# INSPIRE HF 100


OPERATOR´S MANUAL

Please, read this manual carefully before operating the INSPIRE HF100 for the first time. Additionally to the safety information here provided, observe all the precautions detailed in your pump laser Operator´s Manual.



Address: Radiantis, PMT, Av. Canal Olimpic, 08860 Castelldefels, Barcelona, Spain

email: info@radiantis.com

Changes may be made periodically to the information in this document without obligation to notify any person of such revisions or changes.

# TABLE OF CONTENTS

# Chapter I.- Introduction

This manual details information for the user of the INSPIRE HF100, an optical parametric oscillator with integrated frequency doubler that can produce high repetition rate, femtosecond laser outputs which are tunable over a selection of wavelength ranges:

Near Infrared (Pump Laser): 690 nm – 1040 nm
Doubled Fundamental: 345-520 nm
Visible: 490 nm – 740 nm
Mid - Infrared: 930 nm – 2500 nm

For correct operation, the INSPIRE HF100 must be pumped by a mode-locked femtosecond Ti:sapphire laser with ~ 1.5 – 2.9 Watts average power, 80 MHz repetition rate and wavelength range between 690 – 1040 nm. The system has two primary modes of operation: (i) Second Harmonic Generator (SHG), (ii) Optical Parametric Oscillator (OPO). SHG mode generates an output in the range 345 – 520 nm tuned by tuning the Ti:sapphire laser and rotating the second harmonic nonlinear crystal. The OPO generates two simultaneous outputs in the range 490 – 750 nm for the signal and 930 – 2500 nm for the idler for a fixed pump wavelength of 820 nm, tuned primarily by rotating the OPO nonlinear crystal.

The system is not intended to be used with pump lasers of other kind, such as femtosecond lasers with lower repetition rate or higher pulse energies. The use of different pump lasers is not recommend since this may cause permanent damage to the optical components and the system will fail to operate correctly.

Standard pump laser and INSPIRE HF100 specifications are detailed below:

### Pump Laser

Pulse Duration: 80 – 100 fs

Repetition Rate: 80 MHz

Maximum Average Power: 2.9 W

Wavelength Range: 690 – 1040 nm

### INSPIRE HF100

Pulse Duration: 80 – 250 fs

Repetition Rate: 80 MHz

<u>Output Beam 1: Depleted IR Pump</u>

Wavelength Range: 690 – 1040 nm

Average Power at 800 nm: 1.1 W

<u>Output Beam 2: Second Harmonic</u>

Wavelength Range: 345 – 520 nm

Average Power at 400 nm: 1.1 W

<u>Output Beam 3: Idler and/or Depleted Second Harmonic</u>

Wavelength range: 930 – 2500

Average Power: 170mW

<u>Output Beam 4: Signal</u>

Wavelength Range: 490 – 750 nm

Average Power at 550 nm: 350 mW

# Chapter II.- Laser Safety

## 1. General Optical Safety Issues

Unlike light from conventional sources, laser beams have high optical intensities, even after propagation over relatively long distances. The human eye is extremely sensitive to laser radiation and as a result, direct or reflected laser beams can cause permanent damage to the unprotected eye.

Ocular damage can happen at different eye regions such as the retina or the lens and the extent of the damage is determined by the laser irradiance, wavelength, exposure duration, and beam size. Since some eye injuries, such as laser retinal burns, may be painless and the damaging beam sometimes invisible, maximal care should be taken to provide protection for all persons in the laser suite.

## 2. Safety Information for the User

Although the INSPIRE HF100 is not itself a laser source and so does not constitute a laser product, the level of hazard associated to its emission is equivalent to a Class 4 laser product. Additionally, since the INSPIRE HF100 changes the emission wavelength of the pump laser, this affects the nature of the hazard and the necessary precautions to be taken for any system user.

Simultaneous output beams can be generated by the INSPIRE HF100 over a range of wavelengths in the near-ultraviolet (near - UV), the visible and the near-infrared (near - IR) spectral regions. In particular, the frequency-doubled output in the near – UV (which is at half the wavelength of the input beam) and the visible OPO signal output, may represent an INCREASE in hazard over the input beam, EVEN THOUGH THE EMITTED POWER IS LOWER, because of the differing biophysical effects and variations in the maximum permissible exposure (MPE) limits at different wavelengths.

Exposure to any beam directly emitted by the INSPIRE HF100 can result in serious injury to the eye. The viewing of diffuse beam reflections may also be unsafe. In addition, the beam can be hazardous to the skin and poses a risk of fire. It should only be used by those who understand the nature of these hazards and who have undergone appropriate training in laser safety.

Users of the INSPIRE HF100 and their employers are responsible for undertaking a risk assessment and for ensuring that adequate protective measures are established in accordance with the recommendations given in PD IEC TR 60825-14 or other equivalent national or international safety guidelines.

The product should only be used within an enclosed area having suitable restrictions on access. Wherever possible the emitted beams should be enclosed in accordance with good laser safety practice, and remote (i.e. CCTV) viewing systems used for observation if necessary. Where this is not possible and the use of eye protection is necessary, users and their employers are responsible for ensuring that the most appropriate eye protection is used, taking into account both the emitted wavelength and the maximum level of any potential exposure. Particular care is required in selecting eye protection that is intended to provide simultaneous protection for the IR pump beam, its second harmonic and the visible signal. This implies the use of multiple sets of eye protection depending on the signal wavelength in use at any time. Such eye protection will have considerably reduced visible light transmission, and the working area in which the INSPIRE HF100 is used should therefore be well lit, carefully laid out and uncluttered.

## 3. Hazardous Laser Emission

The INSPIRE HF100 has four exit apertures marked as:

LASER APERTURE Beam 1 IR / VIS: 690 – 1040 nm. 4.0 W max

LASER APERTURE Beam 2 UV / VIS: 345 – 520 nm. 2.0 W max

LASER APERTURE  Beam 3  IR: 930 – 2500 nm. 200 mW max

LASER APERTURE  Beam 4  VIS: 490 – 750 nm. 500 mW max

LASER APERTURE Beam 1 is the unconverted output (which is at the same wavelength as the input beam) and represents similar hazard to the input beam (Class 4).

LASER APERTURE Beam 2 is the frequency-doubled output (which is at half the wavelength of the input beam) and may represent an INCREASE in hazard over the input beam EVEN THOUGH THE EMITTED POWER IS LOWER.

LASER APERTURE Beam 3 is the mid infrared idler output which has a power and wavelength which depends on the signal wavelength. This represents a significant hazard due to the invisible nature of the emitted radiation and large range of potential wavelengths emitted.

LASER APERTURE Beam 4 is the visible signal output. This radiation represents a hazard due to the fact that it covers most of the visible wavelength range and therefore multiple sets of protective eyewear are required to protect the user from all the potential emitted wavelengths. Such protective eyewear will reduce the user's vision significantly since it is necessary to block a large fraction of the visible wavelength range.

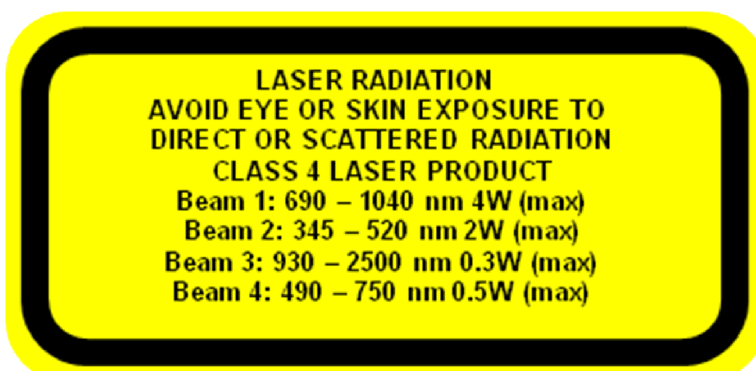
The system is intended to be used with the cover on, which acts as a protective housing from hazardous laser beams and reflections generated inside the box.

## 4. Safety Labels

The INSPIRE HF100 satisfies all labelling requirements. The following are included:

4.1 **Triangular laser warning**: alerts the user to the presence of hazardous visible and invisible laser radiation.

4.2 **Class 4 explanatory label**: alerts the user to the presence of Class 4 visible and invisible laser radiation and specifies the wavelength range and maximum average power emitted by the system at each output.




4.3 **Emission aperture warning labels**: alerts the user to the location of laser radiation exits, the wavelength range and maximum average power emitted. Beam 1 is the depleted pump output, beam 2 is the frequency doubled output, beam 3 is the mid-infrared idler output and beam 4 is the signal output from the OPO cavity.

**LASER APERTURE**

**IR AND VISIBLE**

**Beam 1: 690 – 1100 nm 4W (max)**

**LASER APERTURE**

**UV AND VISIBLE**

**Beam 2: 345 – 550 nm 2W (max)**

**LASER APERTURE**

**IR**

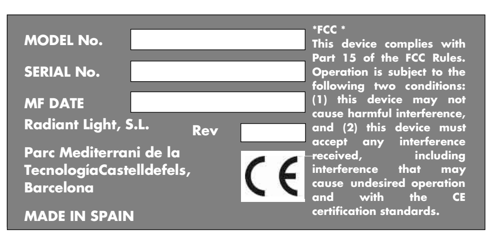
**Beam 3: 930 – 2500 nm 0.3W (max)**

**LASER APERTURE**

**VISIBLE**

**Beam 4: 490 – 750 nm 0.5W (max)**

4.4 Certification and Identification label: Informs the user of the manufacturer name and address, the place, month and year of manufacture and the compliance with International and European laser product safety standards.



## 5. Examples of Suitable Eye Protection

The very broad wavelength coverage of the INSPIRE HF100 means that there is no single pair of laser safety goggles that can protect the eye from the full range of possible output wavelengths. For full protection, a selection of protective eyewear is required and, at any given time, the most appropriate one for the work being carried out and the wavelengths being used should be chosen.

### 5.1 For Ti:sapphire laser, INSPIRE HF100 output Beam 1: IR / VIS, and partial protection for Beam 3: IR and Beam 4: VIS.

Lasermet Ltd. Product reference:
LV-L07K-58
LV-L08K-58

| Wavelength | Optical Density | EN207 markings |
|---|---|---|
| 620 – 690 | >2 | D L2; |
| 690 – 700 | >8 | D L2; |
| 700 – 755 | >8 | D L6; I L8; R L8 |
| 755 – 795 | >8 | D L6; I L8; R L8; M L8 |
| 795 – 805 | >8 | D L5; I L7; R L7; M L8 |
| 805 – 900 | >10 | D L5; I L7; R L7; M L10 |
| 900 – 1050 | >8 | D L5; I L7; R L7; M L8 |
| 1050 – 1320 | >7 | D L5; I L7; R L7 |
| 633 | >5 | D L5; I L5; R L5 |

Visible light transmission: 32%

5.2 Partial protection for Ti:sapphire laser and INSPIRE HF100 laser aperture Beam 1: IR / VIS and Beam 2: UV/VIS:

Lasermet Ltd. Product reference:

LM-A-14

| Wavelength | Optical Density | EN207 markings |
|---|---|---|
| 190 - 315 | >7 | D L7; R L3; M L5 |
| 315 - 534 | >6 | D L4: I L6; R L6; M L5 |
| 730 - 740 | >5 | D L4; I L5; R L5; M L5 |
| 740 - 1064 | >6 | D L4; I L6; R L5; M L5 |

Visible light transmission 11 %

5.3 For INSPIRE HF100 laser aperture Beam 2: UV / VIS, and partial protection for Beam 4: VIS:

Lasermet Ltd. Product reference:

LV-L07K-12

LV-L08K-12

| Wavelength | Optical Density | EN207 markings |
|---|---|---|
| 180 – 315 | >9 | D L9; I L5; R L5 |
| 315 – 515 | >8 | D L6; I L8; R L8 |
| 515 – 578 | >7 | D L6; I L7; R L7 |

Visible light transmission: 10%

5.4 Partial protection for INSPIRE HF100 laser aperture Beam 4: VIS:

Lasermet Ltd. Product reference:

LV-L07-47

LV-L08-47

| Wavelength | Optical Density | EN207 markings |
|---|---|---|
| 580 – 610 | >2 | D L2; I L2; R L2 |
| 610 – 800 | >3 | D L3; I L3; R L3 |

## 5.5 For INSPIRE HF100 laser aperture Beam 3: IR

Lasermet Ltd. Product reference:

LV-L07K-07

LV-L08K-07

| Wavelength | Optical Density | EN207 markings |
|---|---|---|
| 900 – 1050 | >6 | D L6; I L6; R L6 |
| 1050 – 1400 | >7 | D L7; I L8; R L8 |
| 1400 – 3000 | >5 | D L5; I L5; R L5 |

Visible light transmission: 60%

The above eye protection is available from:
Lasermet Ltd
67 Portchester Road
Bournemouth
BH8 8JX
United Kingdom
Tel 44 (0) 1202 770740
www.lasermet.com

# Chapter III. Electrical Safety Instructions

With regard to all electrical installations supplied with the INSPIRE HF100 including the spectrometer, the internal electronics unit, the motorized actuators, the motorized rotation stage and the piezoelectric actuator and driver electronics, for your own safety please refer to qualified personnel for any maintenance work.

## 1. General Safety Considerations

1.1 Water and moisture can seriously damage the equipment and result in personal injuries.

1.2 Do not remove the equipment cover.

## 2. Safe Installation

2.1 Do not cover the equipment slots and openings, provided for ventilation of the equipment.

2.2 Ambient temperature should not be higher than 122°F / 50 °C.

2.3 Do not place the equipment near heat sources or in a highly humid environment.

2.4 Do not place the equipment in a place where it can suffer from vibrations or shocks.

## 3. Safe Operation

3.1 Power requirements for this product are: 110-240 V / 50-60Hz / 0.8A. for an output of 25W maximum and 110-240 V / 50-60Hz / 0.6A. for an output of 15V / 1.2A maximum. This is provided by two external power supplies.

3.2 Should any liquid or object fall into the equipment, please refer to qualified personnel for service.

3.3 To disconnect the equipment from the mains pull on the plug and never by the cable.

3.4 It is strongly recommended not to connect the equipment to the mains until all connections have been carried out.

3.5 The socket outlet shall be installed near the equipment and shall be easily accessible.

# Chapter IV: Description, Operation and Layout

## 1. Description

The INSPIRE HF100 is designed to be pumped by a mode-locked Ti:sapphire laser, with pulse duration 80 - 100 femtoseconds, repetition rate 80 MHz and average powers up to 2.9 W.

The INSPIRE HF100 partially converts the near-IR Ti:sapphire laser emitting between 690 and 1040 nm into a doubled fundamental signal ranging from 345 nm to 520 nm by second harmonic generation. When pumped at 820 nm, the INSPIRE HF100 partially converts the near-IR Ti:sapphire laser into the blue with a wavelength of 410 nm. The converted laser beam is used as the pump beam for the optical parametric oscillator that is integrated within the same box. The optical parametric oscillator converts the blue second harmonic beam into two components, a signal and an idler. A tunable signal beam can be produced that lies in the wavelength range 490 – 750 nm and a tunable idler beam that lies in the range 930 – 2500 nm. For a fixed Ti:sapphire pump wavelength, the wavelength of the signal and idler beams can be tuned by rotation of the OPO´s nonlinear crystal according to the operating instructions in chapter IV. The respective wavelengths of the signal and idler beam are dependent on one another and on the second harmonic pump wavelength. The relationship between the pump, signal and idler wavelengths is given, according to the conservation of photon energy, as follows:

$$1/\lambda_{idler} = 1/\lambda_{pump} - 1/\lambda_{signal}$$

For example for a second harmonic wavelength of 410 nm and a signal wavelength of 600 nm, the idler wavelength is equal to 1346 nm. Increasing the signal wavelength leads to a reduction in the idler wavelength and decreasing the signal wavelength leads to an increase in the idler wavelength.

## 2. System Operation

The INSPIRE HF100 works by exploiting the nonlinear optical effects of advanced crystalline materials. Two principal non-linear optic effects are employed in the INSPIRE HF100: Second Harmonic Generation (SHG) and Optical Parametric Generation (OPG). The first stage of the system involves second harmonic generation of the pump laser whereby two pump photons combine to generate a single photon of twice the energy. By employing angle tuning of a nonlinear material, it is possible to generate the second harmonic, or frequency double the wavelength of the pump laser, with high efficiency at room temperature for the full range of available Ti:sapphire wavelengths. The second harmonic beam can be used as the pump for the second stage of the system, which is the Optical Parametric Generation, in an Optical Parametric Oscillator (OPO). In this stage a single second harmonic photon is split into two photons a Signal and Idler photon. The total energy of the second harmonic photon can be shared between the Signal and Idler photons in an infinite range of possible ways. By placing the nonlinear material inside an optical cavity, to enhance the OPG effect, and once again employing angle tuning of the nonlinear crystal, it is possible to generate Signal and Idler beams, which are continuously tunable over very large wavelength ranges at room-temperature for a fixed pump wavelength.

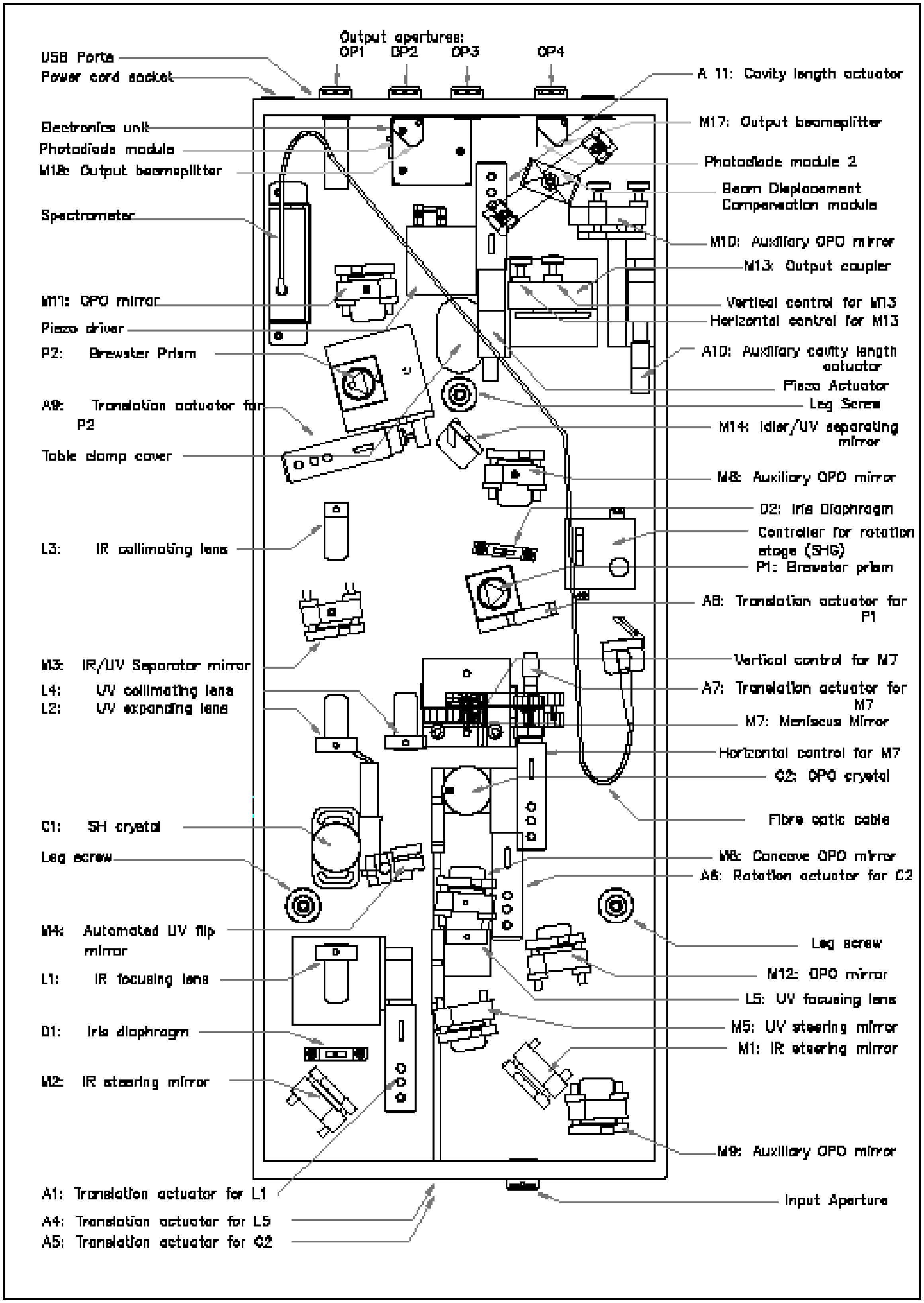
## 3. System Layout

The INSPIRE HF100 is composed of high quality optical, opto-mechanical, and electrical components that have been specially designed and arranged to provide optimum performance and stability, while allowing simple use. These components are secured on a sturdy metal platform that enhances stability and reliability.

The system is provided with a cover that protects the user from hazardous radiation during operation and also protects the internal components from accidental damage, misalignment and dust.

The INSPIRE HF100 also includes an advanced, fully automated control system which comprises a number of motorized actuators and rotation stages as well as an integrated spectrometer and a piezoelectric actuator, controlled through a user-friendly software package. This allows fully automated tuning of the doubled signal and OPO wavelength and precise pulse synchronization between the pump laser and the OPO cavity.

**Figure IV.1** (next page): shows the layout of the INSPIRE HF100 inside the box with the main components labelled. This diagram can be referred to, when reading the installation alignment and operating procedure in the following chapter.



Output apertures:
OP1 OP2 OP3 OP4
USB Ports
Power cord socket
Electronics unit
Photodiode module
M18: Output beamsplitter
Spectrometer
M11: OPO mirror
Piezo driver
P2: Brewster Prism
A9: Translation actuator for P2
Table clamp cover
L3: IR collimating lens
M3: IR/UV Separator mirror
L4: UV collimating lens
L2: UV expanding lens
C1: SH crystal
Leg screw
M4: Automated UV flip mirror
L1: IR focusing lens
D1: Iris diaphragm
M2: IR steering mirror
A1: Translation actuator for L1
A4: Translation actuator for L5
A5: Translation actuator for C2
A 11: Cavity length actuator
M17: Output beamsplitter
Photodiode module 2
Beam Displacement Compensation module
M10: Auxiliary OPO mirror
M13: Output coupler
Vertical control for M13
Horizontal control for M13
A10: Auxiliary cavity length actuator
Piezo Actuator
Leg Screw
M14: Idler/UV separating mirror
M8: Auxiliary OPO mirror
D2: Iris Diaphragm
Controller for rotation stage (SHG)
P1: Brewster prism
A8: Translation actuator for P1
Vertical control for M7
A7: Translation actuator for M7
M7: Meniscus Mirror
Horizontal control for M7
C2: OPO crystal
Fibre optic cable
M6: Concave OPO mirror
A6: Rotation actuator for C2
Leg screw
M12: OPO mirror
L5: UV focusing lens
M5: UV steering mirror
M1: IR steering mirror
M9: Auxiliary OPO mirror
Input Aperture

## 4. Alignment Configurations

There are three principle alignment configurations for the INSPIRE HF100, as shown below.

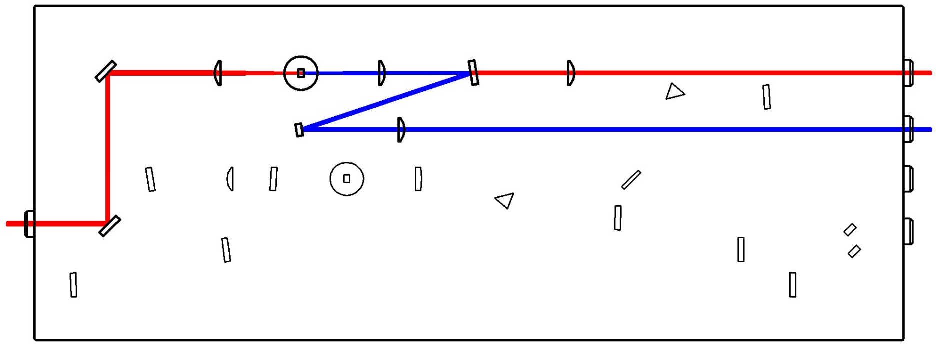


**Figure IV.2.** Second Harmonic Mode. In this configuration the user has simultaneous access to the depleted IR pump beam and the second harmonic beam.

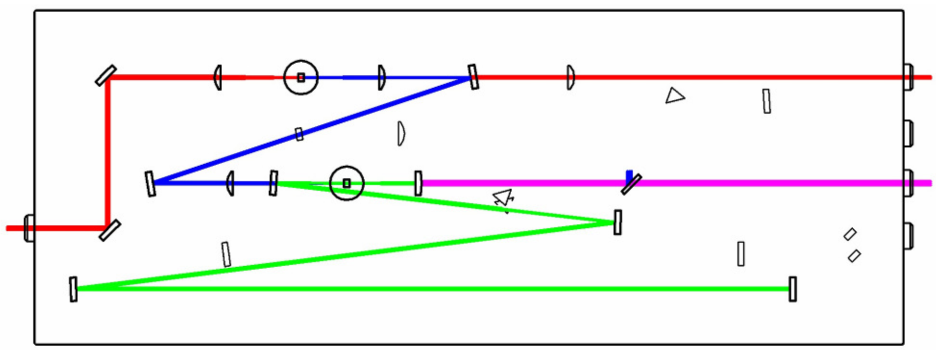


**Figure IV.3.** OPO Alignment / Auxiliary Cavity. This configuration is used only as a first step for alignment of the main cavity.

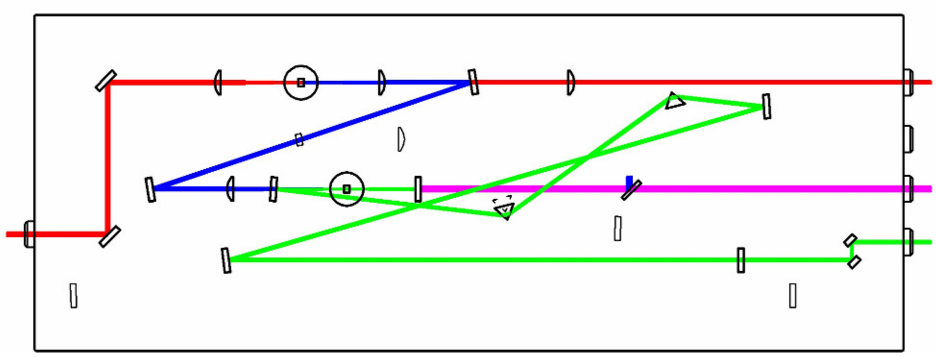


**Figure IV 4.** Main OPO cavity. This configuration includes the main OPO cavity which allows simultaneous extraction of the depleted IR, Idler and Signal beams, including the dispersion compensating prisms.

# Chapter V. Installation, Alignment and Operating Instructions

Note: The INSPIRE HF100 is pre-aligned before shipping to reduce installation time. Avoid misaligning the mirror mounts and translation stages prior to installation. Initial installation is normally carried out by our installation engineers. The following document describes the full alignment procedure to be carried out if the system requires complete realignment by the user.

WARNING: Please read the section on Laser Safety before carrying out any of the following procedures. Exercise caution whenever viewing the laser beams and bear in mind that the INSPIRE HF100 produces both visible and invisible laser radiation. All laser beams in the INSPIRE HF100 are at a fixed height and parallel to the optical table, be extremely careful not to lower your head such that your eyes are level with the height of the laser beam as some of the optical components may produce stray reflections.

## 1. Configuration of Devices and Software Installation

1.1. Install the Ti:sapphire pump laser in accordance with the manufacturer's laser operator manual.

1.2. Place the INSPIRE HF100 on the optical table near the output of the Ti:sapphire laser.

1.3. Install the software according the software installation instructions

1.4. Connect the two power supply cables to the sockets on the output face of the INSPIRE HF100. Connect cables to the mains power and switch on.

1.5. When then software installation is completed, plug both USB cables into output face of the INSPIRE HF100 and connect to PC.

### Software Installation System Requirements: Windows XP/Vista

Please refer to Readme file on the integrated memory key.

## Check Devices

1.6. Use the installed NI Measurement and Automation Explorer to check devices:

1.6.1. Select "Devices and Interfaces - NI- DAQmx Devices" to check and test the USB 6008 DAQ card. If necessary rename as Dev1.

1.6.2. Select "Devices and Interfaces - Serial & Parallel" to find the correct COM port for the USB-serial adapter.

## Start INSPIRE Calibration Program

1.7. To begin installation procedure, run the INSPIRE software provided. When prompted, select "Make Changes" and enter the COM port number for the USB-serial adapter (found using the NI Measurement and Automation Explorer or the Windows Device Manager).

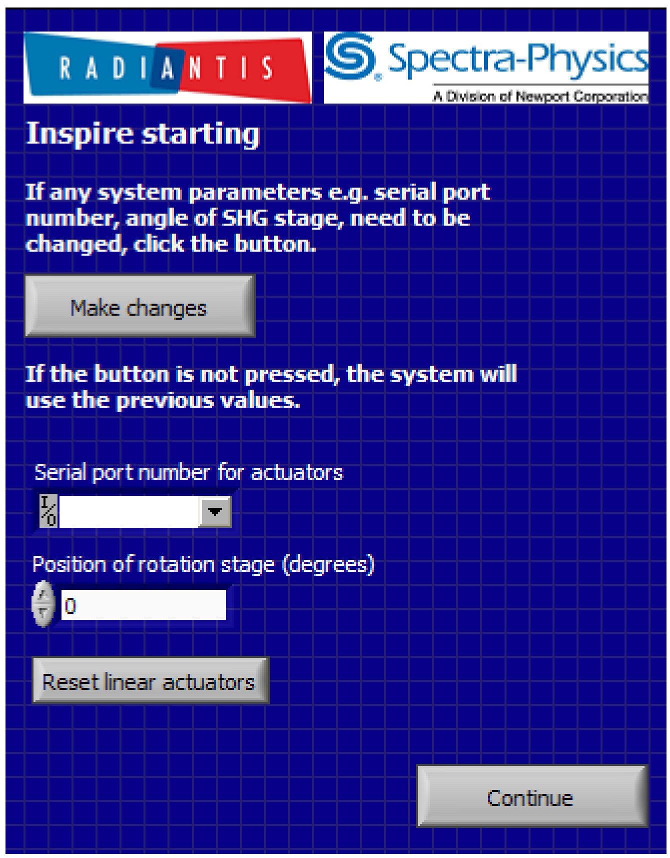



Figure V.1: Prompt Window.

Note: The "Reset Motors" dialogue pops up every time you start the INSPIRE Calibration program and the INSPIRE Control program. To maintain the repeatability of the motors, it is better to leave them connected to the power supply at all times and only click "OK" if there is a problem or if the motors have been disconnected from the power.

The INSPIRE Calibration program, startup interface allows the user to manually set the positions of the motorized actuators and the cavity length, piezo actuator. This control panel is used during installation and alignment of the system.

## 2. Alignment of Integrated Second Harmonic Generator

2.1. Verify that the pump laser beam output characteristics (average power, pulse duration, beam quality and wavelength) satisfy the following:

2.1.1. output average power > 2.5 W

2.1.2. $\lambda$=820nm

2.1.3. pulse duration between 80-100 femtosecond

2.1.4. $M^2$<1.2(vertical) $M^2$<1.2 (horizontal)

For different pump output properties, the INSPIRE HF100 specifications detailed in Chapter VII may not be achieved.

2.2. For alignment, reduce the power of the laser in order to minimize the risk of damage.

2.3. Position the INSPIRE HF100 in front of the pump laser so that its input face is perpendicular to the incoming beam. The recommended beam propagation distance between the exit of the pump laser and the entrance of the INSPIRE HF100 is 10-50 cm. The INSPIRE HF100 can be also positioned in other configurations relative to the pump laser by using 45° turning mirrors (not included) provided that propagation distance remains within the recommended limits.

2.4. Using the handles on each side, remove the cover.

2.5. Adjust the height of the INSPIRE HF100 using the three leg screws so that the incoming beam is level with the centre of the input aperture and all the output apertures are also at the same height as the input aperture.

2.6. When the height is correct, lock the leg screws by turning the thumb screws on each leg so that they press hard against the top of the base plate.

2.7. Ensure that the input beam passes through the centre of the input aperture and hits the centre of M1. The sides of the INSPIRE HF100 should be parallel with the pump laser beam.

2.8. When the position is correct, clamp the feet of the INSPIRE HF100 to the optical table using the 3 clamping forks provided. Two of the clamping forks are fitted on the sides of the INSPIRE HF100 and the third is fitted by removing the small plate next to the leg screw near the centre of the base plate and inserting the clamping fork ensuring that it fits onto the circular foot of the INSPIRE HF100. (See photo)

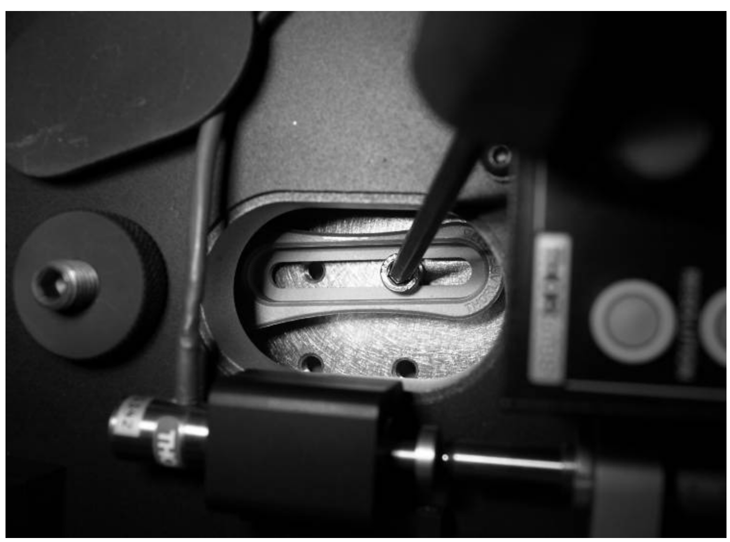


**Figure V.2**: Clamping the INSPIRE HF100 to the optical bench.

2.9. Use the vertical and horizontal tilt angle controls on M1 to position the beam reflection on the centre of M2.

2.10. Partially close diaphragm D1 and output aperture OP1 to diameters of approximately 1 mm. Place a beam stop outside of output aperture 1.

2.11. Use the vertical and horizontal tilt angle controls on M2 to centre the reflected beam with respect to output aperture 1. (Remove the output tube to view the beam position, being careful to avoid exposing any of the cables to the beam).

2.12. Use vertical and horizontal tilt angle controls on M1 to centre the beam with respect to diaphragm D1.

2.13. Repeat steps 2.11 and 2.12 until the beam above is centred with respect to the two apertures.

2.14. Check that the fundamental beam passes through the centre of lenses L1, L2 and L3, and through the centre of mirror M3. If the beams are far from the centre of these optics, check the alignment again (steps 2.11, 2.12 and 2.14). If there is still a problem remove the two lenses and their mounts, then repeat steps 2.11, 2.12 and 2.14 with the optics removed. Then carefully replace each component ensuring that, for each one, the beam passes through the centre of the output aperture.

2.15. Block the beam by fully closing the INSPIRE HF100 input aperture or use a beam stop. Remove the cover of crystal C1 by loosening the screw on top and carefully removing the cover. Unblock the beam and check that it passes close to the centre of crystal C1.

2.16. On the Inspire software program, press "SHG" button, then "Find". The Inspire Blue Control user interface should pop up on the screen and mirror M4 will be placed on the doubled beam path. Press the "Find" button to run the procedure.

When the blue power is optimised, check where the back reflected beam form the crystal lies. The back-reflection of the beam on the crystal should **NOT** pass directly though the diaphragm since this can cause feedback to the laser and loss in performance. Instead, the back-reflection should be approximately 2 mm below the centre of diaphragm D1. If necessary adjust the vertical tilt of the crystal using a small Allen key in the tilt stage upon which the crystal is mounted. The diaphragm should be left partially closed to ensure that the back-reflected beam is blocked, whilst avoiding loss to the input beam.

2.17. Block the beam again and carefully replace the crystal cover.

2.18. For safety, fully close output aperture OP1. Place a beam stop outside output aperture OP2 and partially open output aperture OP2.

2.19. Keeping diaphragm D1 partially closed to minimise input power for safety, increase the Ti:sapphire power such that stable, mode-locked operation is achieved and the specification outlined in step 2.1 are achieved.

2.20. Use horizontal and vertical controls on mirror M3 to centre the second harmonic beam with respect to mirror M4.

2.21. Use the horizontal and vertical tilt controls on mirror M4 to centre the second harmonic beam with respect to output aperture OP2.

2.22. Place a power meter in front of output aperture OP2, fully open the output aperture and fully open diaphragm D1.

2.23. For a pump power of 1.6 to 2.9 W the doubling efficiency should be approximately 40 – 50 %. Consult Radiantis if the achieved efficiency differs greatly from this value. The INSPIRE HF100 should function properly if the second harmonic power is greater than 800 mW.

## 3. Alignment of visible OPO auxiliary alignment cavity

3.1. Align the integrated second harmonic generator as described above if necessary.

3.2. Close diaphragm D1 to the minimum diameter to reduce the second harmonic power during alignment.

3.3. Press the "Back to Inspire" button on the Inspire Blue control user interface to go back to the main calibration interface and remove mirror M4 from the beam path.

3.4. The second harmonic beam should hit the centre of mirror M5. If it does not, use the horizontal and vertical controls on mirror M3 to centre the second harmonic beam with respect to M5. (After step 3.4 it may be necessary to press the SHG "Optimise" button again to access the doubled beam from output OP2 and repeat step 2.21, 2.21 and 2.22 to ensure that the second harmonic beam is still aligned with output aperture OP2).

3.5. Partially close output aperture OP3 to about 2 mm diameter. If necessary, remove mirror M14 from the base plate so that the blue beam can be viewed at the output aperture.

3.6. Using the PC interface, click on "reset to default" (or "reset to last saved" if you have previously saved the positions or run a calibration) and wait a few moments for the motors to complete their motion. Check that the horizontal tilt of mirror M7 is approximately at normal incidence to the blue beam.

3.7. Use the horizontal and vertical controls on mirror M5 to centre the second harmonic beam with respect to diaphragm D2.

3.8. Check that the second harmonic beam passes very close to the centres of mirrors M6 and M7 and the centre of output aperture OP3. Using the horizontal and vertical controls on mirrors M3 and M5, repeat steps 3.4 to 3.8 until this alignment becomes very precise. **This step is critical for the subsequent correct alignment of the system.**

3.9. Remove the cover of crystal C2 as in step 2.15. Check that the beam passes close to the centre of the crystal.

3.10. While the cover is off, rotate crystal C2 using the "OPO crystal angle control" on the PC interface, to normal incidence with respect to the second harmonic beam. Look for the blue reflection from C2 on the back of diaphragm D1. If necessary adjust the vertical tilt of the crystal using the tilt stage so that the back reflected beam passes through diaphragm D1.

3.11. The position of the focusing lens L5 and crystal C2 in the optic axis (z) are controlled by actuators A4 and A5 respectively. (The separation of the two curved mirrors is very critical. Avoid adjusting this separation with actuator A7 unless a problem occurs with the following procedure.)

3.12. The centre of the crystal should be at a distance of exactly 75 mm from the centre of mirror M7. The micrometer setting for actuators A5 and A7, to achieve the correct crystal position, are given on the installation engineer's calibration report. Check that the micrometers match the values in the report.

3.13. Close input and carefully replace the crystal cover.

3.14. Using actuator A4 adjust the position of lens L5 so that the focal plane of the second harmonic beam lies at the centre of the crystal. There are two useful indicators for finding the correct focal position:

3.14.1. Fully open diaphragm D1 and look at the second harmonic beam spot on mirror M7. When the focus is near the centre of the crystal, faint interference rings can be seen around the outside of the beam spot.

3.14.2. Place a power meter in front of output aperture OP3 and fully open the aperture as well as diaphragms D1. There should be a small drop in power when the focus lies at the centre of the crystal due to intensity dependent absorption in the crystal. Minimise this power to achieve optimum focusing.

3.15. Close diaphragm D1 again to about 1 mm diameter.

3.16. Place a beam stop between the crystal C2 and mirror M7 to block the reflected beam from M7.

3.17. Translate prism 1 using actuator A8, all the way out of the beam path so that the second harmonic beam reflected from mirror M6 (the back reflection from the crystal C2) hits mirror M8. Partially close diaphragm D2.

3.18. The second harmonic beam should pass through the centre of diaphragm D2 and hit the centre of mirror M9. If necessary use an Allen key to adjust the horizontal and vertical tilt of mirror M6 to achieve this then fully open diaphragm D2.

3.19. Use the horizontal and vertical controls on mirror M8 to ensure the second harmonic beam hits the centre of mirror M9.

3.20. Use the horizontal and vertical controls on mirror M9 to ensure the second harmonic beam hits the centre of mirror M10.

3.21. Now remove the beam stop from M7. Using the vertical tilt controls on mirror M7, and the PC interface to control the horizontal tilt of M7 ("end mirror tilt"), align the reflection of the second harmonic beam so that is passes back through diaphragm D1.

3.22. Now place a small piece of white card directly in front of mirror M10 to view the reflected second harmonic beams. Two spots should now be visible on the card (if necessary turn off the laboratory lights to improve your vision of the spots). When the vertical control on M7 is adjusted, the reflection from mirror M7 will move vertically. The spot which does not move is the reflection from crystal C2. Use the vertical control on mirror M7 to shift the spot up by 2 – 3 mm relative to the other spot. Use the PC interface to adjust the horizontal position of the spot so that it lies directly above the stationary spot.

3.23. Check that the two spots are equal in size and have diameters of approximately 1 mm to 1.5 mm. If one spot is larger than the other the focusing position of lens L5 may be incorrect. Repeat step 3.14 if necessary whilst observing the size of the two spots. If satisfied jump to step 3.25.

3.24. Optimising the Curved Mirror Separation

If it becomes difficult to achieve optimum focusing, by the technique described in steps 3.14, whilst simultaneously achieving equal spot sizes, it may be necessary to adjust the position of crystal C2 and the separation of mirrors M6 and M7 using actuators A5 and A7 as described below.

3.24.1. First write down the micrometer readings for actuators A5 and A7 so that the positions can be returned to if necessary.

3.24.2. Block the second harmonic beam before it hits mirror M7 by placing a beam stop on the translation stage in front of the mirror.

3.24.3. Check that the focus of the pump beam lies in the centre of the crystal by the method described in step 3.14.

3.24.4. Now look at the size of the spot reflected by crystal C2 on the card in front of mirror M10. The spot should have a diameter of approximately 1 mm and the beam between mirrors M6 and M10 should be well collimated. Check using a piece of white card that the reflected beam remains collimated, without focusing to a very small spot, between mirrors M6 and M10. If necessary, move actuators A4 and A5 in small, equal sized steps of about 0.1 mm in the same direction by reading the micrometer settings. Between each step look to see if the collimation of the reflected beam has improved. If it gets worse, change direction of the steps.

3.24.5. When good collimation of the reflected beam is achieved simultaneously with optimum focusing in the crystal, remove the beam stop in front of mirror M7 and look at the second spot on the card in front of mirror M10, the reflection from M7.

3.24.6. Using actuator A7, translate mirror M7 until the two spots on the card become the same size.

3.25. Now using the vertical control on mirror M7 move the position of the bright spot on the paper so that it lies exactly on top of the faint spot.

3.26. Remove the paper. With the laboratory lights dimmed it should now be possible to view the back-reflected blue spot from mirror M10 close to mirror M9.

3.27. Using the horizontal and vertical controls on mirror M10 adjust the position of the back reflection so that it passes exactly back along the input path and maps onto itself on mirrors M9 and M8.

3.28. Ensure all the diaphragms are fully open and translate mirror M10 using actuator A10 so that the micrometer screw is at the highest value on the scale.

3.29. Now, with the laboratory lights turned off or dimmed, slide the translation stage connected to mirror M10 manually, by pushing on the mobile section of the stage, across the entire range of motion. (See Figure V.3)

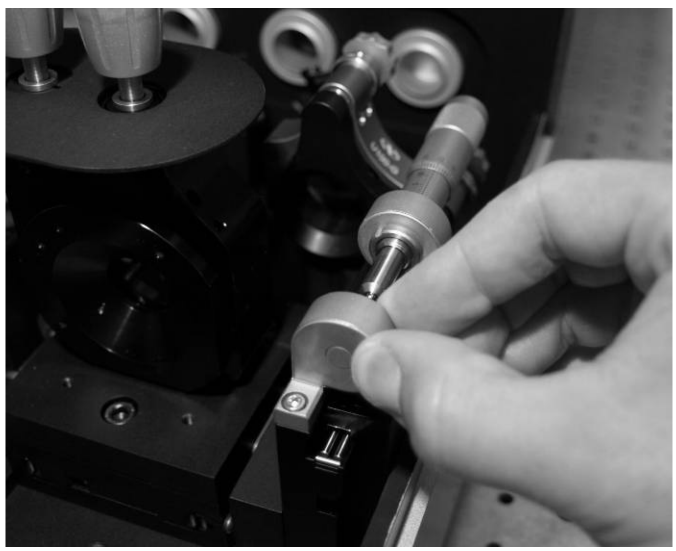


Figure V.3: Sliding the alignment cavity output coupler to observe a flash.

3.30. When looking at any of the mirrors M8, M9 or M10, it should be possible to observe a flash of coloured light (green or yellow) when the OPO is properly aligned. Try sliding the stage slowly to make sure you don't miss it.

3.31. If it doesn't work first time (which is common), repeat steps 3.24 to 3.30 and try again. Try also making very small adjustments to the controls on mirror M10 while sliding the translation stage back and forth.

3.32. When a flash is observed use actuator A10 to move the translation stage back to the position where the flash occurred. With fine control of the actuator, it should now be possible to maintain operation of the OPO.

3.33. Once the OPO is working it will be necessary to fine tune the alignment. By adjusting the horizontal and vertical controls of the cavity end mirror M10, try to maximise the brightness of the intracavity beam and minimise the appearance of higher order spatial modes. Between each small adjustment, correct the cavity length (actuator A10) to maximise the brightness. If the OPO stops working at any time, try to return the controls to the last position where the OPO worked and adjust the cavity length. If it still fails to work return to step 3.25.

3.34. Now adjust the horizontal and vertical controls on mirror M7 to try to ensure that the visible OPO beam spots on the two curved mirrors M6 and M7 lie on the centre of the mirrors and that the brightness of the intracavity signal is maximised. Similarly make small adjustments and regularly correct the cavity length to maintain the operation of the OPO and maximise the brightness of the intracavity beam. Repeat step 3.34 if necessary until the pump and signal beams between mirrors M6 and M7 are concentric and collinear.

3.35. It will also be possible to observe the spatial mode profile of the OPO signal beam by looking at the signal spot on mirror M7. Try to produce a single-lobed circular beam (ie. $TEM_{00}$). Small adjustments of the lens and crystal positions with actuators A4 and A5 may also help. Don't worry if the beam profile is not $TEM_{00}$ at this stage. It should improve when the main cavity is aligned.

## 4. Alignment of visible OPO main cavity

4.1. Once the alignment cavity has been optimised as described in steps 3.34 – 3.35, translate prism P1 using actuator A8 towards the resonating signal beam.

The apex of the prism should be partially inserted into the beam so that a portion of the intracavity power becomes extracted and deflected by the prism. Try to insert the prism as much as possible but stop before the brightness of the resonating beam drops significantly and the OPO becomes unstable.

**4.2.** Now follow the path of the deflected beam to the second prism P2. Adjust the position of the prism if necessary using the prism position control on the PC interface so that the beam passes well inside the prism > 2 mm from the prism apex. The prisms should already be aligned at the correct angle and orientation such that the deflected beams should propagate at a fixed height (the same height as the input pump beam). If the prisms have been changed or removed it may be necessary to realign them according to step 4.3. **If not go to step 4.4.**

### 4.3. Adjusting the alignment of the prisms

**4.3.1.** Start with prism P1. Loosen the set screw on the prism tilt stage so that the prism mount can be rotated freely. Look at the reflection of the signal beam from the input surface of the prism on a piece of white paper or card. Rotate the prism slowly to find the position where the brightness of the reflected beam is minimised (Brewster´s angle). This will need to be done with careful positioning of the prism translation stage so that the OPO continues to work over the range of angles of close to the optimum angle. When the correct angle is found hold the prism mount still and lock the set screw. (See Figure V.4).

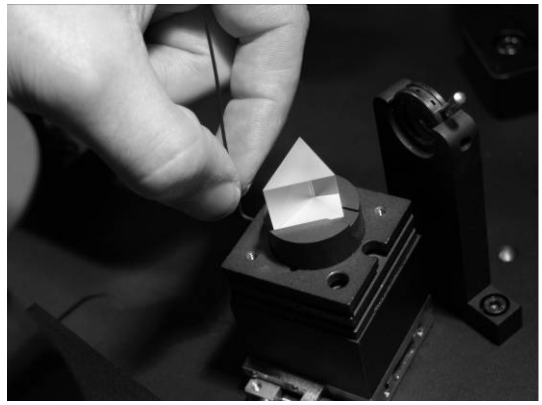


Figure V.4: Setting the prism angle.

4.3.2. Now use a diaphragm or alignment aperture set at the height of the input pump laser beam and check that the reflection from the prism is at the correct height and parallel with the optical table. If necessary adjust the orientation of the prism tilt stage in the plane perpendicular to the translation stage direction, to achieve the correct beam height.

4.3.3. Now look at the part of the beam which is deflected by the prism. Translate prism P2 all the way out of the path of the deflected beam and check using the same alignment aperture or diaphragm that the height is the same and the beam is parallel with the optical table. If necessary adjust the tilt stage in the opposite plane. (See Figure V.5)

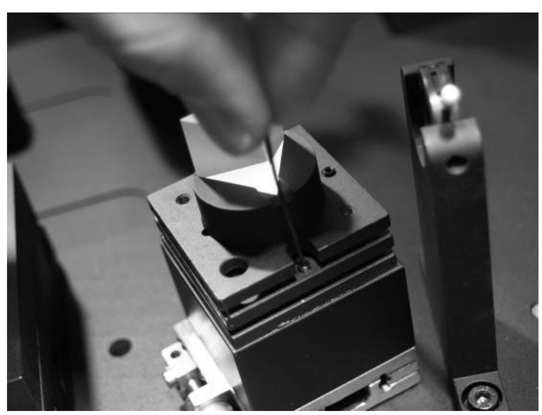


Figure V.5: Adjusting the prism tilt.

4.3.4. Repeat steps 4.3.2 and 4.3.3 until the transmitted and reflected beam are at the same height.

4.3.5. Reinsert prism P2 into the beam path and repeat the process (step 4.3.1 to 4.3.4) for the second prism. (In this case the prism is inserted completely into the beam so finding the correct orientation is a little easier).

4.4. Now follow the beam deflected by prism P2 to mirror M11. The beam should be in the central portion of the mirror. Now adjust the horizontal and vertical controls on mirror M11 so that the reflected beam goes through the hole in the mirror mount for mirror M7 and hits mirror M12. It is important that the beam goes through the centre of the hole in the mount with maximum clearance from the sides (even if it is not perfectly centred horizontally on mirror M12).

4.5. Now adjust the horizontal and vertical controls on mirror M12 so that the beam hits the centre of the output coupler mirror M13.

4.6. Look at mirror M12 while adjusting the horizontal and vertical controls on mirror M13 and look for the back reflection of the signal beam. When you can see it, align the back-reflection with the incoming beam spot on the mirror.

4.7. Now look at mirror M11 and by adjusting the controls on mirror M13, try to map the back-reflected beam onto the incoming beam. (Hint. Adjust the vertical position of the back-reflected spot so that it lies about 1mm above the incoming beam, then adjust the horizontal position and look for a third spot above the back-reflected spot. This is the second order reflection from mirror M7. Aim to map this second order spot onto the incoming spot to achieve good cavity alignment.)

4.8. Translate prism P1 using actuator A8 into the signal beam until the OPO stops working, then continue to translate it an additional 2 – 3 mm.

4.9. Using the user interface set the "cavity length motor" position to zero and wait a moment for the stage to move. Now, with the laboratory lights off or dimmed, scan the cavity length of the main cavity, by pushing on the mirror mount, across the full range of the translation stage and look at mirror M11 or M12 to try to observe a flash of light of the same colour as the previously obtained OPO signal beam. If no flash is observed translate the prism out of the beam again so that the alignment cavity functions once again. Then repeat steps 4.1 and 4.7 – 4.9 again.

4.10. Once a flash is observed, adjust the cavity length using the "cavity length motor" control on the PC interface. Set the approximate position by increasing the step number in units of 10000 (approx 1mm) until a flash is observed. (Remember to wait a moment after each adjustment for the motor to complete its motion). Then click on "Coarse Cavity Length Scan" and wait for the program to find the optimum cavity length.

4.11. Now fine tune the horizontal and vertical controls on mirror M13 whilst correcting the cavity length using the control on prism P1, so that once again the signal beam becomes collinear and concentric in relation to the second harmonic beam between mirrors M6 and M7. Adjust mirror M7 if necessary to achieve this.

4.12. In order to ensure that the beam goes through the centre of aperture OP4 for the complete wavelength range, a Beam Displacement Compensates (BDC) is incorporated. Alignment should be done as follows:

4.12.1. Ensure the beam goes through the centre of M13. This is a critical step.

4.12.2. Loosen the centre screw of the BDC.

4.12.3. Look at the reflection of the signal beam from the input surface of the first prism on a piece of white paper card. Carefully rotate the BDC to find the position where the brightness of the reflected beam is minimized and the deflected beam is hitting the centre of M15. Tight the centre screw of the BDC.

4.12.4. Use the fine adjustment screw of M15 to get the beam in the centre of M16.

4.12.5. Use the fine adjustment screw of M16 to get the deflected beam of the second prism in the centre of the output aperture OP4. Note: It is important that the beam travels about 2 mm from the prism apex.

4.13. If necessary adjust the horizontal and vertical controls on mirrors M15 and M16 so that the output beam goes through the centre of output aperture OP4 and also remains parallel with the sides of the INSPIRE HF100 box.

4.14. Fully open output aperture OP4, place a power meter in front of output aperture OP4 and measure the output power of the signal beam.

4.15. Assess the beam profile by looking at the shape of the beam on mirror M7. By fine tuning the cavity end mirrors, and the cavity length, try to maximise the output power whilst simultaneously achieving a stable circular $TEM_{00}$ beam spot on the centre of mirror M7. Small adjustments of the lens and crystal positions with actuators A4 and A5 may also help.

4.16. The horizontal tilt of mirror M7 should be optimised by making small adjustments to the "end mirror tilt" control on the PC interface. Make small adjustments of + / - 10 steps to try to optimise the power.

## 4.17. Adjusting the prism positions

The amount of dispersion compensation in the OPO cavity depends on how much the prisms are inserted into the intracavity beam. Initially, aim to have the centre of the beam travelling through each of the prisms about 2 - 3 mm from the apex. Later, more careful optimisation of the position can be applied: See section 8.

**4.17.1.** To adjust the position of prism P1 use the prism translation stage actuator A8. Move the prism in the desired direction (the OPO will stop working due to the effective change in cavity length).

**4.17.2.** To regain operation of the OPO click "Coarse Cavity Length Scan" on the PC interface and wait while the cavity length actuator searches for the OPO signal.

**4.17.3.** To move prism P2, follow the same procedure move the prism using the "prism position" control on the user interface. To regain OPO operation, click the "Search Peak" button as above.

## 4.18. Calibrating the system

When you are satisfied with the cavity alignment and the output power is optimised it will be make the INSPIRE self-calibrate using the PC interface. First carefully replace the cover and adjust the piezo voltage on the PC interface to regain operation of the OPO and maximise the power displayed on the screen. If the piezo voltage is far from the central position, press "Recenter" to recenter it. Check that the output power is not significantly reduced with the cover on (if necessary re-optimise the alignment then replace the cover).

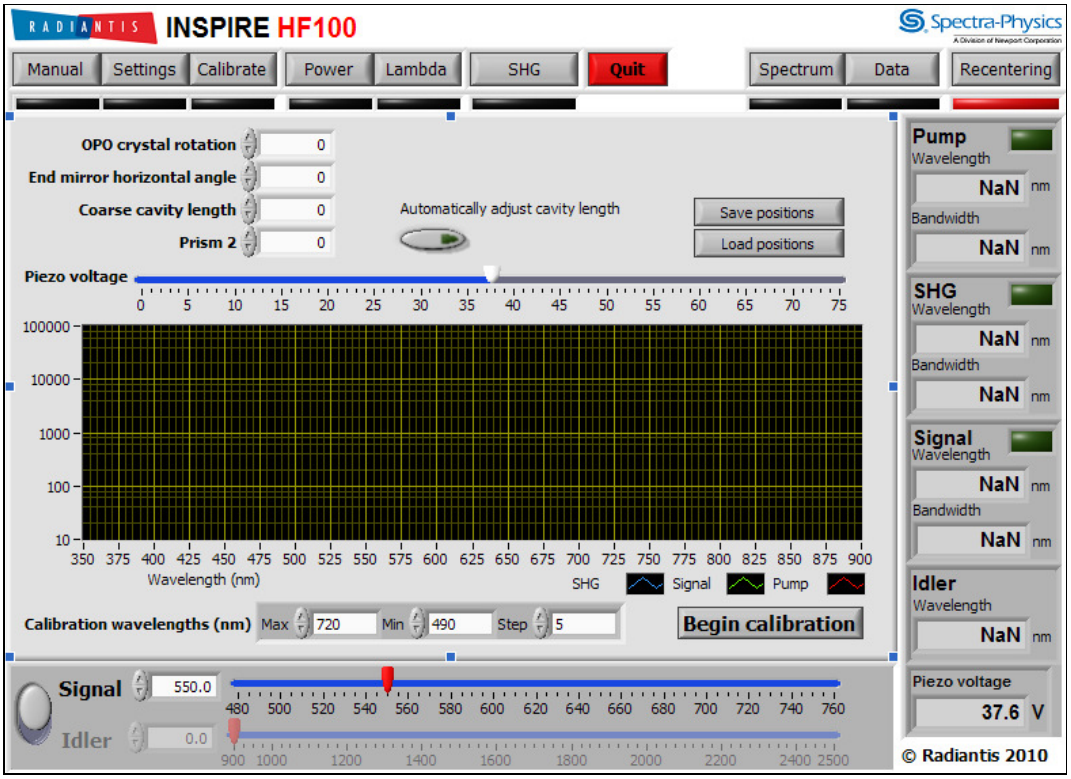



Figure V.6: Inspire Software interface.

At any stage it is possible to save the current motor positions which can then be recalled using the "Load positions" button. When everything is ready, press the "Begin Calibration" button.

Depending on the calibration settings, the calibration typically routine takes about 30 mins, during which time, it is possible to view the spectra of the points as they are generated, as well a plot which shows the peak powers and the measured wavelengths. Use this to check the calibration.

## 5. Running the INSPIRE

After the INSPIRE has been calibrated, it is possible to use the INSPIRE using the same software interface.

## 5.1. Setup Mode

When the system has finished initializing, the user can change some key parameters by clicking “Setup” and a configuration page will be displayed. Various system parameters can be changed in this pane.

## 5.2. Manual Mode

This mode can also be used for stable operation of the OPO over short timescales of several minutes with low noise; however there is no active stabilization in Configuration mode, so longer term stability is not maintained.
The plot shows the complete spectrum measured by the spectrometer from 350 to 900 nm. Three different wavelength signals may be measured simultaneously using this function. The IR pump at 820 nm, the SHG at 410 nm and the visible signal (default wavelength 555nm). The relative intensities for the three signals is normally very different, so it is usually necessary to adjust the vertical zoom and the integration time in order to measure each one. It may also be necessary to adjust the position of the spectrometer fibre cable mount to ensure that the three green lights for “PUMP”, “SHG” and “SIGNAL” are all illuminated. You can also use the slider control to adjust the piezo voltage manually to optimize the signal power. The banner on the right hand side of the screen displays the measured parameters for the IR pump beam, the SHG beam and the visible Signal beam. Additionally the wavelength of the Idler beam is given, which is calculated from the pump and signal wavelength and the current piezo voltage is also displayed. The horizontal zoom functions can be used to select a smaller wavelength range to show a more detailed spectral shape.

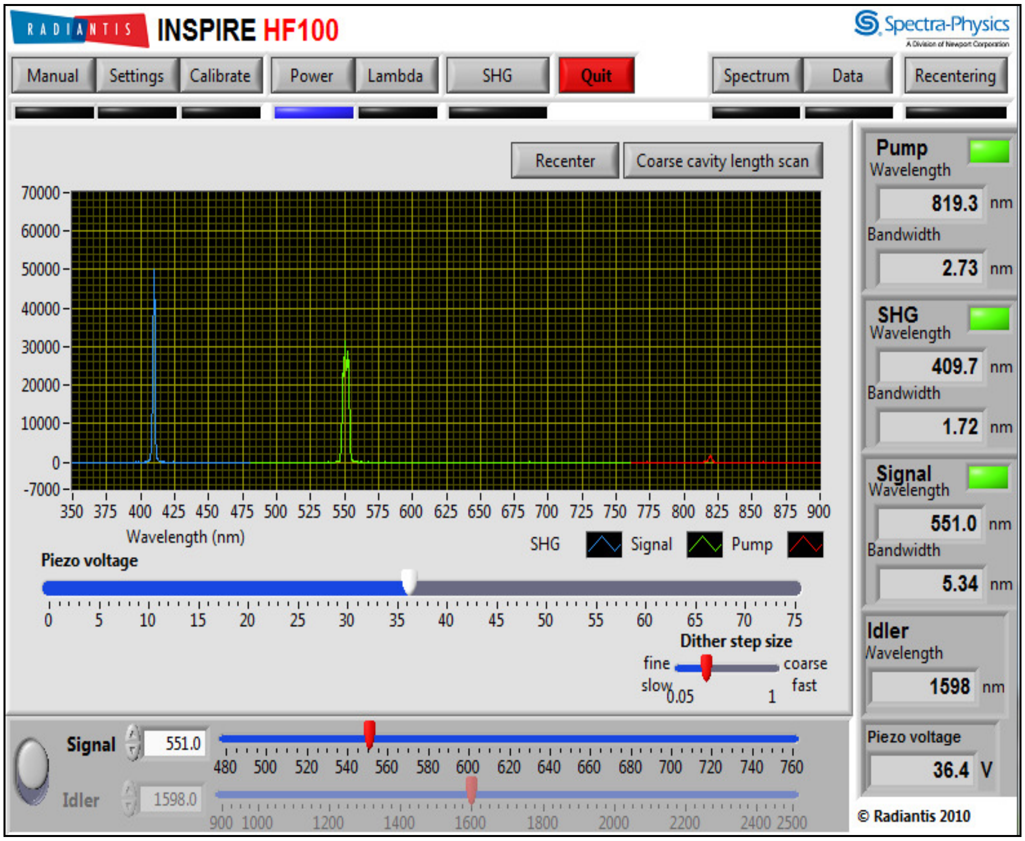



Figure V.7. Inspire software interface.

## 5.3. Power Mode

Once the OPO is correctly configured, the user can switch to "Power" mode, shown in Figure V.7. This mode uses the values from the latest calibration table to determine the motor positions for any target wavelength. Once the positions are set, the program enters into a stabilization loop, which controls the cavity length using the piezo, to maintain maximum output power of the OPO signal.

The user can select a target signal wavelength either using the digital control or the slider bar. As soon as the target wavelength is changed, the motors will tune within a few seconds, to the new positions and the stabilization loop will restart. The user can easily switch between, signal and idler target wavelength using the control switch at the bottom left of the screen.

Piezo voltage displayed at the bottom right of the screen spans the range from 0 to 75 volts. It should normally remain between about 20 and 50 volts. If it drifts outside of this range the user can click the "recenter" button to adjust the cavity length motor in order to recenter the piezo.

## 5.4. SHG Mode

When the "SHG" button is pressed, mirror M4 is flipped and the doubled signal beam is accessible through output 2.

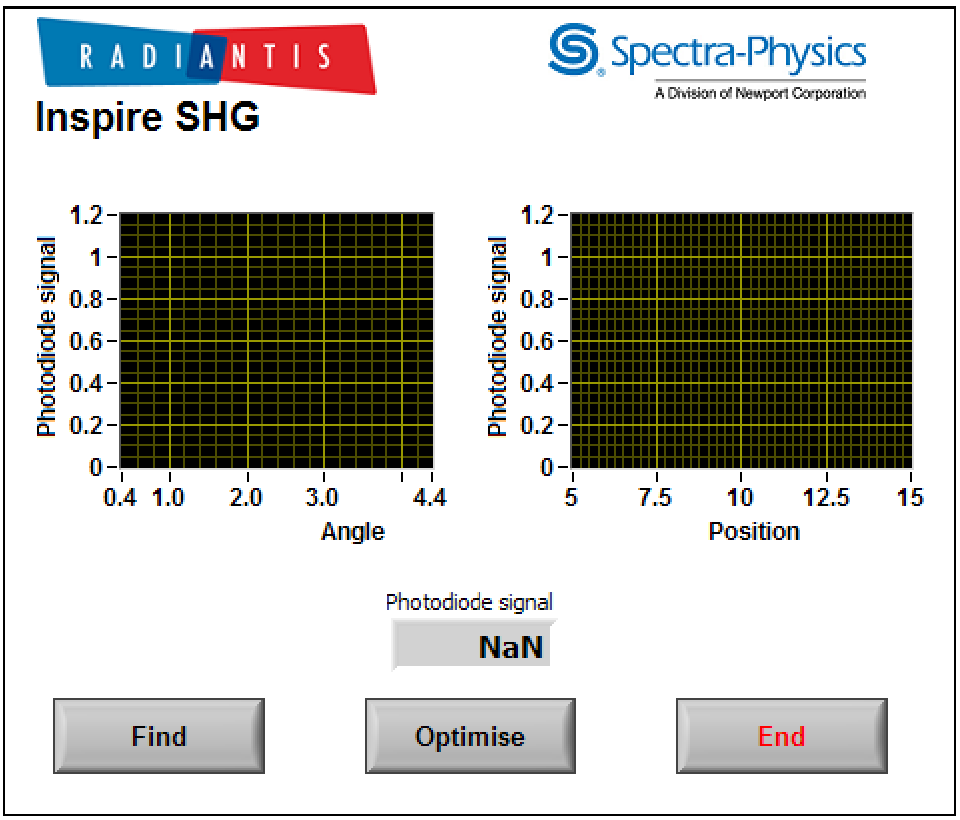



Figure V.8. "SHG" mode.

The program is in an idle state in which the voltage read from the photodiode is displayed in volts. Pressing the "End" button closes this interface. Mirror M4 is flipped out of the doubled signal beam path and the system goes back to the Inspire configuration and user interface.

The “Find” procedure has to be launched by pressing the “Find” button so the program optimizes the power of the doubled signal.

When the “Find” procedure has been performed and the system has been idle for a long time, the doubled signal power might decrease. In that case, the “Optimise” procedure can be run to make sure the power is optimized. This is useful to repeak the SHG if the pump conditions or ambient temperature has changed.

Whenever the pump wavelength is modified significantly, the user should run the “Find” procedure again.

Just as before, pressing the “End” button closes this interface. Mirror M4 is flipped out of the doubled signal beam path and the system goes back to the Inspire configuration and user interface.

## 5.5. Log Data

Clicking on “Log Data” at any time will create a comma delimited .txt file into which the data for the Pump, SHG and Signal beams, displayed on the right hand side of the screen, will be saved at a sample period set by the user. The software will continue to log the data until the “Log Data” button is clicked once again. The file will be saved to the folder specified in Setup mode.

## 5.6. Save Spectrum

Clicking on “Save Spectrum” at any time will save the complete current spectrum read by the spectrometer to a comma delimited .txt file. The file will be saved to the desktop.

## 5.7. Setup

When the software is running, select “Setup” to adjust the system settings.

### 5.7.1. Peak Detection Thresholds

For maximum sensitivity, the peak detection thresholds for the signal, pump and SHG beams should be minimised but such that when the pump beam is blocked the three "detected?" indicators on the right hand side of the screen turn black. These don't normally need to be adjusted unless the integration time of the spectrometer has been changed a lot.

### 5.7.2. Piezo Recentering

The "Piezo Recentering" function enables the cavity length to be stabilized over long periods, even when the ambient temperature is varying. When it is running, the cavity length will recenter periodically with the period set by the user. This causes a momentary drop-out of the OPO operation every time the cavity recenters. This can be stopped if not required.

### 5.7.3. Calibration Table

The "Calibration Table" box allows the user to reinitialise the current calibration table and search for the signal if the signal is lost or if the program failed to find the peak during the start-up initialise routine.

The user can also select an earlier version of the calibration table if preferred. After selecting an earlier version, click "Initialise this version" to start using the earlier version.

### 5.7.4. Paths for Saved Data

The paths for the Saved data give the location where the log data and save spectrum files are saved. This can be modified by the user if required. The sample period control allows the user to set the period for the data logging.

## 6. Extracting the Idler Beam

6.1. With mirror M14 removed both, the idler and the depleted second harmonic beams are emitted from output aperture OP3. In general the depleted second harmonic power will be much larger than the Idler power.

6.2. If only the idler output is required, block the input aperture and replace mirror M14 at an incidence angle of 45° to the depleted pump beam. Screw it to the base plate such that the depleted pump is reflected onto the integrated beam stop.

6.3. Unblock the input beam and fully open output aperture OP3. Use an IR viewing card to check that the idler beam is emitted from the output aperture.

## 7. Extracting the IR beam

7.1. By opening output aperture OP1, the depleted IR pump beam can be accessed. This can be extracted simultaneously with any of the other outputs. Check that the beam is well collimated by propagating it 2 or 3 meters across the laboratory to a beam stop. If necessary remove the cover and translate lens L3 by loosening its base screw and sliding along its track to improve the beam collimation.

Note 1: When the crystal C1 is well aligned for second harmonic generation the IR power from output aperture OP1 will be depleted by approximately 50%. As a result the spectral and temporal pulse shape may be significantly distorted from the original input pulse shape and the pulse duration may be increased.

Note 2: Mirror M3 transmits a small fraction of the second harmonic light (<1%) which is also transmitted through output aperture OP1. If necessary this can be separated from the IR light by the use of further wavelength separating mirrors or filters (not provided) outside of the INSPIRE HF100 box.

## 8. Extracting the UV / Blue Beam

8.1. The second harmonic beam can easily be extracted from the INSPIRE HF100 giving access to UV and Blue emission in the range 345 – 520 nm.

8.2. From the Inspire Calibration program, press the “Optimise SHG” button. From the Inspire Control program, press the “Run SHG” button.

8.3. Place a beam stop in front of output aperture OP2 and open the aperture. Check that the second harmonic beam goes through the centre of the output aperture and if necessary adjust the horizontal and vertical controls on mirror M4 to centre the beam with respect to the output aperture.

8.4. Using folding mirrors if necessary, propagate the second harmonic beam 2 or 3 meters across the laboratory to a hit beam stop and check that the beam is well collimated. If necessary, translate lens L4 by loosening its base screw and sliding it along its track to improve the beam collimation.

8.5. In this configuration, tuning the output wavelength requires tuning of the Ti:sapphire pump source. Tune the pump source to the desired wavelength (twice the desired second harmonic wavelength) in accordance with the manufacturer’s laser operators manual.

8.6. Place a power meter in front of output aperture OP2.

8.7. Using the Inspire Blue Control program, optimise the doubled signal power. Refer to section 5.3 for more details.

## 8.8. Simultaneous UV and Visible Option

If the UV / Blue output is required simultaneously with the OPO signal or Idler outputs, it is possible to replace mirror M4 with a partially reflective mirror (provided as an optional extra). Provided that the pump power is sufficiently high, the OPO will function properly with mirror M4 translated fully into the beam path. In this configuration, the OPO signal and idler outputs will have lower output power, but the UV / Blue output will be emitted simultaneously with a similar output power to the OPO signal.

Note: When the second harmonic beam is transmitted through mirror M4, it may change the alignment of the second harmonic beam when it focuses into the OPO crystal, C2. If the OPO performance becomes poor, it may be necessary to adjust the horizontal and vertical controls on mirror M3 to improve the second harmonic beam alignment. If the OPO ceases to work, realignment of the OPO using the above procedure may be required.

# Chapter VI. Daily Operation and Maintenance

## Daily Operation

It is recommended to leave the INSPIRE HF100 connected to the mains power at all times. This helps to prolong the repeatability of the motorized actuators and therefore increases the period required before recalibration. Other factors which help to make the calibration last longer are to avoid removing the cover as much as possible, avoid shock to the table or box, to avoid applying pressure or place objects on top of the INSPIRE HF100.

When starting up the INSPIRE Control program, there is no need to make changes unless the motors have been disconnected from the power supply or there is some problem, or the COM port number has changed. Note on some computers the COM port may change without any apparent action from the user.

Check that the Ti:sapphire laser is warmed up and operating at correct wavelength (820 nm) and the shutter is open. Select “OK” when prompted to “Search Peak” This procedure should allow the system to regain OPO operation every day.

If the coarse cavity length scan fails to find the peak try running it again. If it fails a second time, restart the program and this time click “OK” when prompted to reset motors. Try this several times and if it still fails, call a service engineer for advice.

Recalibration should normally be required between once a week and once a month, depending on system usage and performance. If the power drops over time, re-calibration may not be required. First remove the cover and check that the SHG unit is optimised, (the laser wavelength may have drifted slightly). Also small adjustments to the vertical tilt controls on the cavity end mirrors M7 and M13 may recover the power loss. If the power loss is not recovered or if the OPO signal wavelength differs greatly from the target wavelength set on the PC interface, then recalibration would be recommended. In which case follow the procedure described in section 4.18 and Error! Reference source not found. to recalibrate the system.

## General Maintenance

To prolong the lifetime of the INSPIRE HF100, insure that it is kept in a clean, dry, dust-free environment. When transporting the INSPIRE HF100, at least 2 people are required to carefully lift the unit, holding the base and avoiding excessive shock. Avoid use in low ambient temperature and/or high humidity as condensation can form which may cause damage to optical components. Avoid spilling chemicals on or in the INSPIRE HF100 as this can cause damage to optical and mechanical components. Ensure that the cover remains on whenever possible to protect components from dust and other hazards and to protect users from stray laser radiation.

Cleaning optics: To optimise the performance of the INSPIRE HF100, the mirrors and lenses may be cleaned periodically without removing them from their mounts. Use clean compressed air to remove dust from optics. Only when necessary, a lint-free lens tissue and a suitable solvent such as methanol can be used to wipe the mirrors´ and lens´ surfaces by a gentle wipe towards the edge of the mirrors (optics). Avoid over cleaning as this may result in scratches developing and loss in performance. The non-linear crystals are enclosed in protective housing which should only be removed with great care as the crystal is very fragile and should be protected from dust. Cleaning the crystal should be limited to gentle blowing of clean compressed air over the surface to remove dust. **DO NOT USE any chemical liquid or spray to clean the surface of the non-linear crystals as this will result in damaging the crystals.** Radiantis accepts no responsibility for damage of the crystals or mirrors caused by cleaning, mishandling or dust.

## Chapter VII. Warranty

The Warranty does not apply to any product from which the serial number has been removed or that has been damaged or rendered defective (a) as a result of accident, misuse or other external causes; (b) by operation outside the usage parameters stated in the Operator´s Manual; or (c) by modification, adaptation or service by anyone other than (i) Radiantis, (ii) Spectra Physics, or (iii) authorized service provider of either Radiantis or Spectra Physics.

# Chapter VIII. Specifications

| INSPIRE HF Specifications[1] | | |
|---|---|---|
| **Output Characteristics[2]** | **Inspire HF 50** | **Inspire HF 100** |
| Averange Power | | |
| SHG @ 400 nm | n/a | 1100 mW |
| Signal @ 550 nm | 350 mW | 350 mW |
| Depleted Fundamental @ 800 nm | 1100 mW | 1100 mW |
| Idler | 170 mW | 170 mW |
| Pulse Width | | |
| SHG | n/a | <140 fs |
| Signal | 200 fs | 200 fs |
| Depleted Fundamental | <140 fs | <140 fs |
| Idler | 200 fs | 200 fs |
| Tuning Range | | |
| SHG | n/a | 345–520 nm |
| Signal (Simultaneous with Idler) | 490–750 nm | 490–750 nm |
| Depleted Fundamental | 690–1040 nm | 690–1040 nm |
| Idler (Simultaneous with Signal) | 930–2500 nm | 930–2500 nm |
| Repetition Rate | 80 MHz | |
| Noise | <1% rms | |
| Wavelength Stability @ 555 nm | <0.5 nm | |
| Spatial Mode | TEMoo, $M^2$ <1.2 (Signal) | |
| Polarization | Horizontal for Signal and Idler<br>Vertical for SHG | |
| Spectrometer for UV and Visible Range[3] | 350–900 nm (integrated into optics unit) | |
| Dimensions (W x L x H)[4] | 14.2 x 37.6 x 9.1 in (36.0 x 95.4 x 23.2 cm) | |

**Table VII.1.- INSPIRE HF Specifications**

Notes: [1]. Specifications are subject to change without notice.

[2]. Pumped by Mai Tai® HP Ti: Sapphire oscillator, 2.8 W, 100 fs, 820 nm.

[3]. For IR spectral region, contact Spectra-Physics.

[4]. PC controllable. No control electronics unit required.

## Annex I.- Glossary

| ABBREVIATION | DESCRIPTION |
|---|---|
| $\lambda$ | Lambda (Wavelength) |
| fs | Femtosecond ($10^{-15}$ Seconds) |
| IR | Infrared (Wavelength) |
| SHG | Second Harmonic Generation |
| MHz | MegaHertz ($10^{6}$ Hertz) (Repetition Rate) |
| mm | Millimetres ($10^{-3}$ meters) (Dimensions) |
| mW | MilliWatts ($10^{-3}$Watts) (Average Power) |
| nm | Nanometers ($10^{-9}$ meters) (Wavelength) |
| OPO | Optical Parametric Oscillator |
| TEM | Transverse Electromagnetic (Beam Profile) |
| Ti:sapphire | Titanium Sapphire |
| UV | Ultraviolet (Wavelength) |
| W | Watts (Power) |

Table AI.1.- Abbreviations

## Annex II. Contact Details

For technical support, please contact our technical staff at:

Tel: +34 934 134 167

E-mail: technical@radiantis.com

Address:
Radiantis
Edificio CIMNE
Parc Mediterrani de la Tecnologia
Av. Canal Olimpic
08860 Castelldefels
Barcelona
Spain