LIGHT CONVERSION

GMP
GENERAL MICROTECHNOLOGY & PHOTONICS

FEMTOSECOND LASER SYSTEMS FOR SCIENCE

PRODUCT CATALOG

2021

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LIGHT CONVERSION

Founded in 1994 as a Vilnius University spin-off, LIGHT CONVERSION is now a major ultrafast laser technology company with over 300 employees, 10% of which hold PhD degrees, and more than 5000 installed systems worldwide. LIGHT CONVERSION designs and manufactures ultrafast lasers, oscillators, optical parametric amplifiers (OPAs), optical parametric chirped pulse amplifiers (OPCPAs), and spectroscopy systems for industrial and scientific applications.

LIGHT CONVERSION TOPAS and ORPHEUS series of OPAs constitute around 80% of the global continuously wavelength-tunable ultrafast light source market. Ultrafast laser applications are covered by the PHAROS and CARBIDE lasers. PHAROS is designed for basic research as well as material processing applications with a focus on customizability, reliability and process-tailored laser output parameters. CARBIDE is a compact industrial-grade femtosecond laser with air- and water-cooled models reaching average powers of up to 80 W. LIGHT CONVERSION also produces HARPIA – a comprehensive femtosecond and nanosecond pump-probe spectroscopy and microscopy system.

LIGHT CONVERSION has over 15 years of experience in managing international R&D projects. LIGHT CONVERSION was one of the key technology providers for the single-cycle SYLOS laser at the ELI-ALPS facility delivering CEP-stabilized 6.6 fs pulses with a peak power of 4.9 TW at 1 kHz.

With a proven competence in the design and manufacture of lasers, OPAs and spectroscopy systems combined with close ties to research programs at Vilnius University and state-of-the-art R&D facilities, LIGHT CONVERSION offers unique solutions for today's most challenging ultrafast laser technology and application problems.

1994 Founding

1995 First worldwide distributor

2000 Service center in Japan

2005 Multiple partnerships as OEM supplier for TOPAS products

2006 USA office

2013 New facilities >3 610 m²

2016 China Office

2017 OPCPA for ELI-ALPS

2018 HQ >6 500 m²; S.Korea Office

2020 Laser Focus World Innovators Awards Platinum & Gold Honoree

TOPAS
optical parametric amplifiers

1994; **1999** SHBC; **2002** TOPAS-White; **2004** TOPAS-HE; **2006** TOPAS-C; **2011** TOPAS-Prime, TOPAS-Twins, HE-TOPAS-Prime; **2014** TOPAS-HR

PHAROS
femtosecond lasers

2006 0.2 mJ; **2008** industrial 24/7; **2009** 10 W; **2012** 20 W; **2017** BiBurst; **2020** PHAROS-PH2 2 mJ, 20 W

FLINT
femtosecond Yb oscillators

2007; **2011** FLINT-FL1 for RRL and CEP; **2015** FLINT-FL1 8 W; **2017** FLINT-SP 40 fs; **2018** FLINT-FL2 20 W

ORPHEUS
optical parametric amplifiers

2008 ORPHEUS-N; **2009** ORPHEUS; **2012** ORPHEUS-TWINS; **2013** ORPHEUS-HP, ORPHEUS-PS; **2014** ORPHEUS-ONE, I-OPA-FW; **2016** ORPHEUS-F, ORPHEUS-HE; **2020** ORPHEUS-MIR, CRONUS-3P, I-OPA-TW

HARPIA
spectroscopy systems

2012; **2017** HARPIA-TA; **2018** HARPIA-TF, HARPIA-TB; **2019** HARPIA-MM

CARBIDE
femtosecond lasers

2013 5 W; **2015** industrial 24/7; **2017** CARBIDE-CB3 40 W; **2018** BiBurst; **2020** CARBIDE-CB3 80 W

Contents

PHAROS

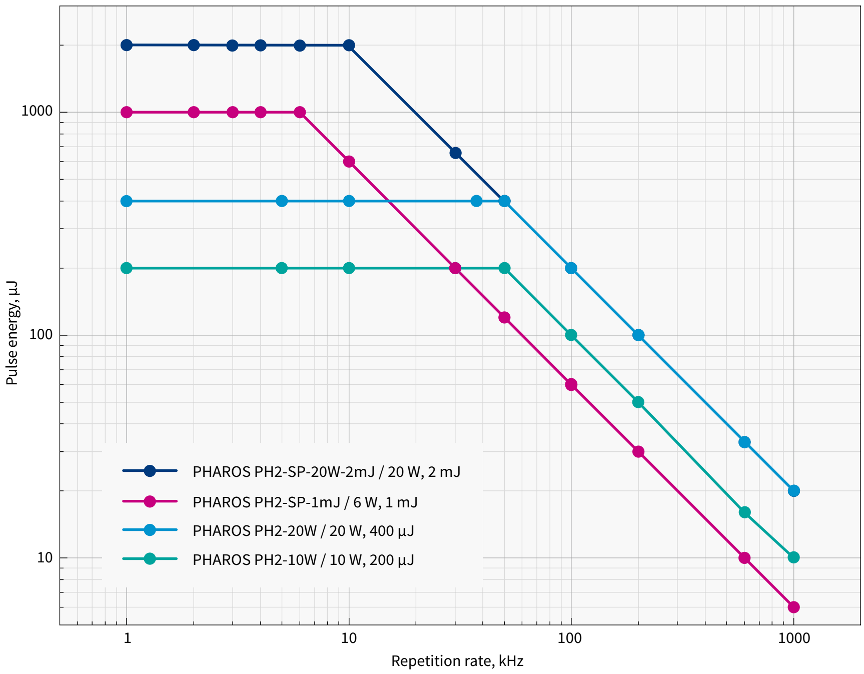
Modular-Design Industrial-Grade Femtosecond Lasers

FEATURES

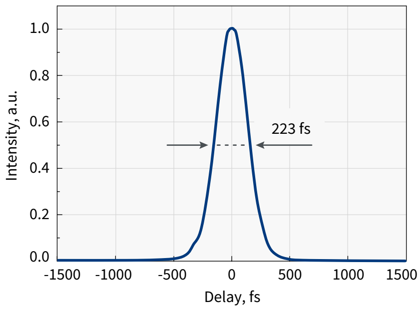
- 190 fs – 20 ps tunable pulse duration
- 2 mJ maximum pulse energy
- 20 W maximum output power
- Single-shot – 1 MHz repetition rate
- Pulse picker for pulse-on-demand mode
- Industrial-grade design
- Optional automated harmonic generator
- Optional CEP stabilization
- Optional repetition rate locking to an external source

PHAROS is a series of femtosecond lasers combining millijoule pulse energy and high average power. PHAROS features a mechanical and optical design optimized for both scientific and industrial applications. A compact, thermally-stabilized, and sealed design enables PHAROS integration into various optical setups and machining workstations. Diode-pumped Yb medium significantly reduces maintenance costs and provides a long laser lifetime, while the robust optomechanical design enables stable operation in varying environments.

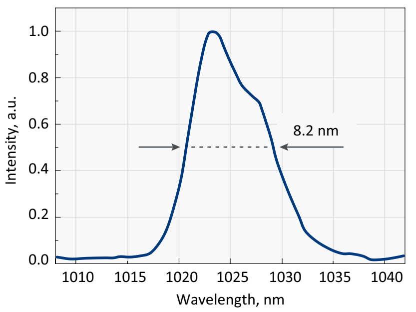
The tunability of PHAROS allows the system to cover applications normally requiring multiple different laser systems. Tunable parameters include pulse duration (190 fs – 20 ps), repetition rate (single-shot – 1 MHz), pulse energy (up to 2 mJ), and average power (up to 20 W). A pulse-on-demand mode is available using the built-in pulse picker. The versatility of PHAROS can be extended by a variety of optional modules.



Pulse energy vs fundamental repetition rate of PHAROS



Typical pulse duration of PHAROS



Typical spectrum of PHAROS

SPECIFICATIONS

Model [1]	PH2-10W	PH2-15W	PH2-20W	PH2-SP-1mJ	PH2-SP-20W-2mJ
OUTPUT CHARACTERISTIC					
Maximum output power	10 W	15 W	20 W	10 W	20 W
Pulse duration [2]	< 290 fs			< 190 fs	
Pulse duration tuning range	290 fs – 10 ps (20 ps on request)			190 fs – 10 ps (20 ps on request)	
Maximum pulse energy	0.4 mJ			1 mJ	2 mJ
Repetition rate	Single-shot – 1 MHz				
Pulse selection	Single-shot, pulse-on-demand, any fundamental repetition rate division				
Center wavelength [3]	1030 ± 10 nm				
Polarization	Linear, horizontal				
Beam quality	TEM_{00} ; $M^2 < 1.2$			TEM_{00} ; $M^2 < 1.3$	
Beam diameter [4]	2.5 mm			2.9 mm	4.3 mm
Pulse-to-pulse energy stability [5]	RMS deviation [6] < 0.5% over 24 h				
Long-term power stability	RMS deviation [6] < 0.5% over 100 h				
Beam pointing stability	< 20 µrad/°C				
Pre-pulse contrast	< 1 : 1000				
Post-pulse contrast	< 1 : 200				

OPTIONAL EXTENSIONS

Oscillator output	Optional. Contact *sales@lightcon.com* for more details or customized solutions
Typical output	1 – 6 W, 50 – 250 fs, ≈ 1035 nm, ≈ 76 MHz; available simultaneously
Harmonic generator	Integrated, optional *(see page 8)*
Output wavelength	515 nm, 343 nm, 257 nm, or 206 nm
Optical parametric amplifier	Integrated, optional *(see page 15)*
Tuning range	320 – 10000 nm
BiBurst option	Tunable GHz and MHz burst with burst-in-burst capability, optional *(see page 9)*
GHz-Burst	
Intra burst pulse period [7]	200 ± 40 ps
Number of pulses, P [8]	1 ... 25
MHz-Burst	
Intra burst pulse period	≈ 15 ns
Number of pulses, N	1 ... 9 (7 with FEC)

PHYSICAL DIMENSIONS

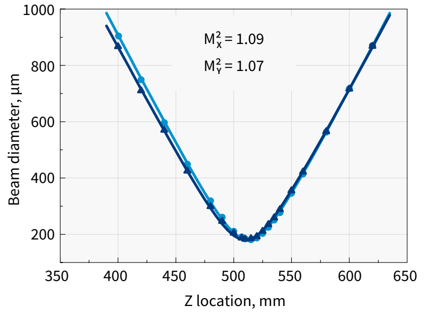
Laser head (L × W × H) [9]	780 × 419 × 230 mm
Chiller (L × W × H)	590 × 484 × 267 mm
24 V DC power supply (L × W × H) [9]	280 × 144 × 49 mm

ENVIRONMENTAL & UTILITY REQUIREMENTS

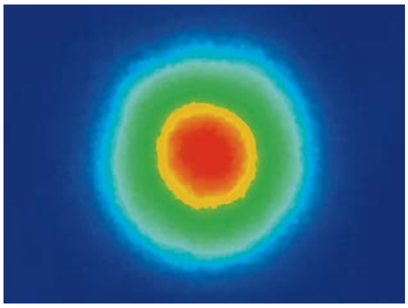
Operating temperature	15 – 30 °C (air conditioning recommended)
Relative humidity	< 80% (non-condensing)
Electrical requirements	110 V AC, 50 – 60 Hz, 20 A or 220 V AC, 50 – 60 Hz, 10 A
Rated power	1000 W
Power consumption	600 W
Electrical requirements (chiller)	100 – 230 V AC, 50 – 60 Hz
Rated power (chiller)	1400 W
Power consumption (chiller)	1000 W

[1] *More models are available on request.*
[2] *Assuming Gaussian pulse shape.*
[3] *Precise wavelengths for specific models are available on request.*
[4] *FWHM, measured at laser output, using maximum pulse energy.*
[5] *Under stable environmental conditions.*
[6] *Normalized to average pulse energy, NRMSD.*
[7] *Custom spacing is available on request.*
[8] *Maximum number of pulses in a burst depends on the laser repetition rate. Custom number of pulses are available on request.*
[9] *Dimensions might increase for the lasers with integrated optional modules.*

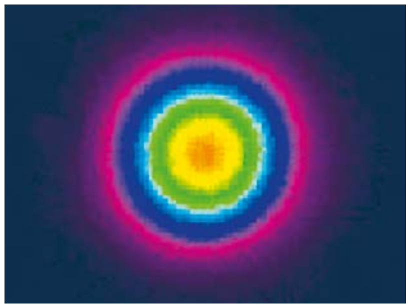
DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT



Typical M² measurement data of PHAROS

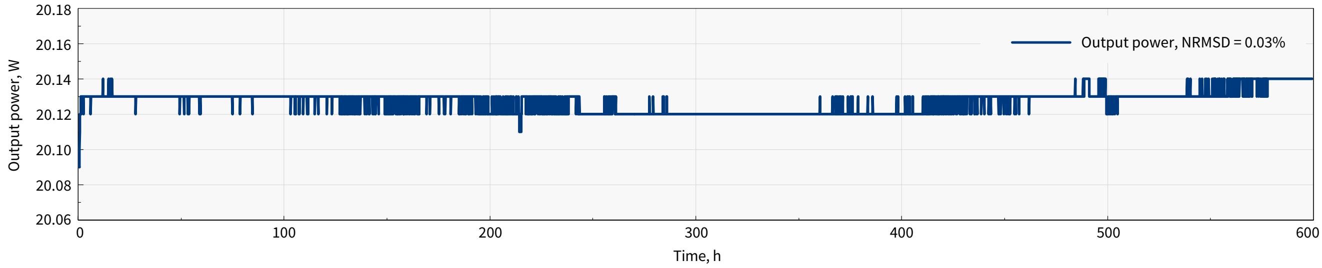


Typical near-field beam profile of PHAROS at 200 kHz

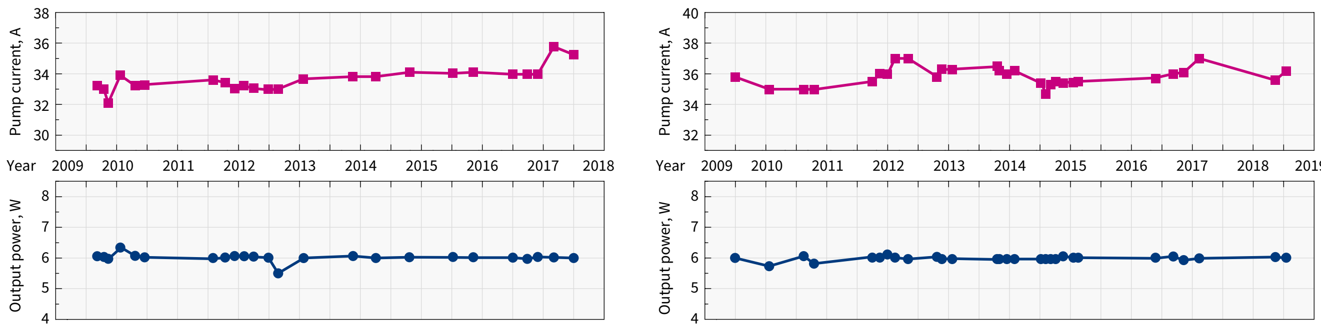


Typical far-field beam profile of PHAROS at 200 kHz

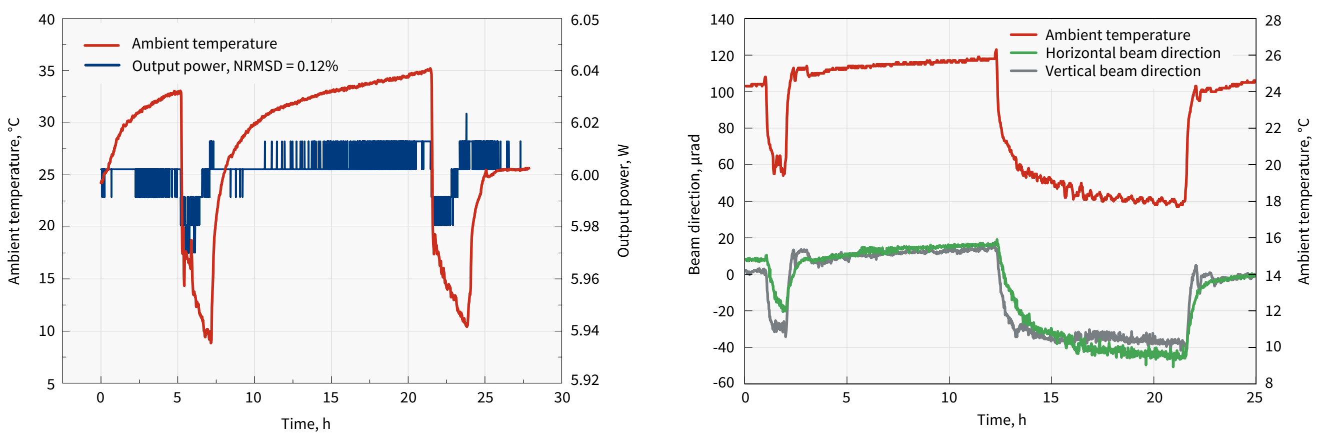
STABILITY MEASUREMENTS



Long-term power stability of PHAROS



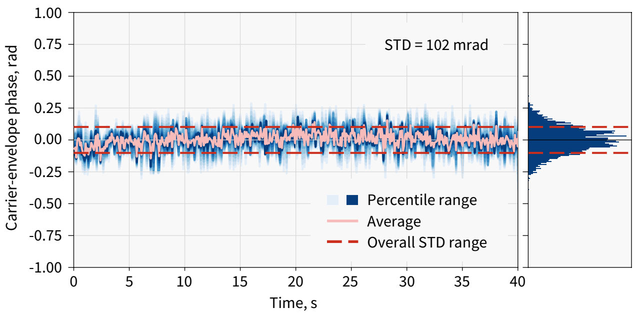
Output power of industrial-grade PHAROS lasers operating 24/7 and current of pump diodes during the years



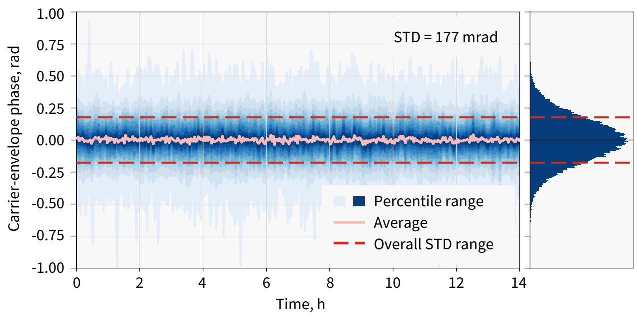
PHAROS output power and beam direction with power lock enabled, under harsh environmental conditions

CEP STABILIZATION

PHAROS lasers can be equipped with feedback electronics for carrier-envelope phase (CEP) stabilization of the output pulses. The carrier-envelope offset (CEO) of the PHAROS oscillator is actively locked to 1/4th of the repetition rate with a < 100 mrad standard deviation. The CEP stable pulses from the synchronized amplifier have a < 350 mrad standard deviation. The CEP drift occurring inside the amplifier and the user's setup can be compensated with an out of loop f-2f interferometer, which is a part of the complete PHAROS active CEP stabilization package.



Short-term CEP stability of PHAROS operating at 200 kHz repetition rate

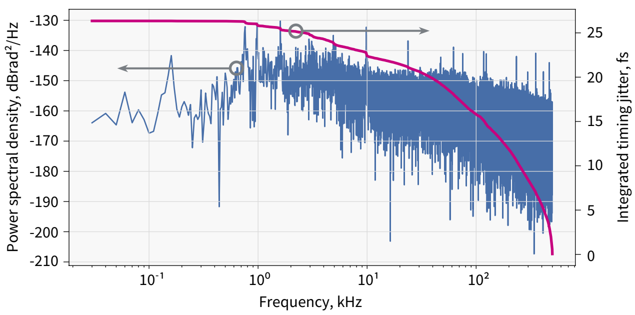


Long-term CEP stability of PHAROS operating at 200 kHz repetition rate

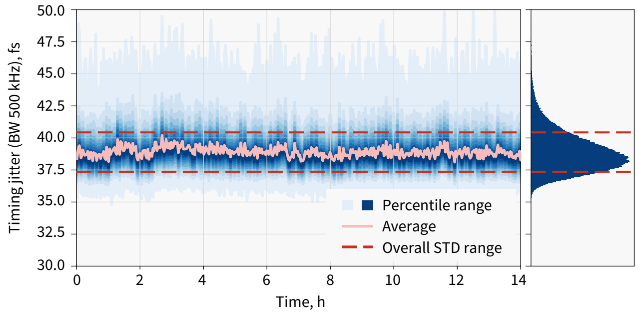
REPETITION RATE LOCKING

The oscillator of PHAROS laser can be customized for repetition rate locking applications. Coupled with the necessary feedback electronics, the repetition rate is synchronized to an external RF source using the two piezo stages installed inside the cavity.

The repetition rate locking system can assure an integrated timing jitter of less than 200 fs for RF reference frequencies larger than 500 MHz. Continuous phase shifting is available on request.

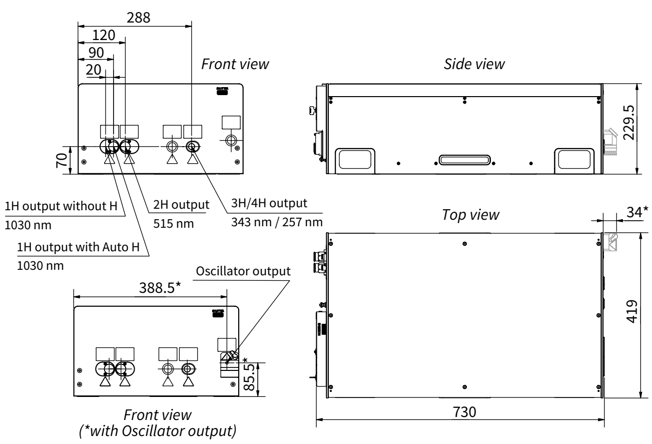


Phase noise data of PHAROS oscillator locked to a 2.8 GHz RF source



Timing jitter stability over 14 h;
PHAROS oscillator locked to a 2.8 GHz RF source

DRAWINGS



PHAROS-PH2 laser PH2-730 housing drawing

HG | PHAROS

Automated Harmonic Generators

Harmonic generator attached to PHAROS

FEATURES

- 515 nm, 343 nm, 257 nm, or 206 nm output
- Automated harmonic selection
- Mounted directly on the laser head
- Industrial-grade design

PHAROS lasers equipped with automated harmonic generators (HGs) provide a selection of fundamental (1030 nm), second (515 nm), third (343 nm), fourth (257 nm), or fifth (206 nm) harmonic outputs using software control.

HGs are perfect for industrial applications that require a single-wavelength output. Modules, mounted directly at the output of the laser, are fully integrated into the system.

SPECIFICATIONS

Model		2H (-HE)	2H-3H (-HE)	2H-4H (-HE)	4H-5H
Output wavelength [1] (automated selection)		1030 nm 515 nm	1030 nm 515 nm 343 nm	1030 nm 515 nm 257 nm	1030 nm 257 nm 206 nm
Pump pulse energy		20 – 2000 µJ	50 – 2000 µJ [2]	20 – 2000 µJ [2]	200 – 1000 µJ
Pump pulse duration		190 – 300 fs			
Conversion efficiency		> 50% (2H)	> 50% (2H) > 25% (3H)	> 50% (2H) > 10% (4H) [3]	> 10% (4H) [3] > 5% (5H) [4]
Beam quality (M^2)	≤ 400 µJ pump	< 1.3 (2H), typical < 1.15	< 1.3 (2H), typical < 1.15 < 1.4 (3H), typical < 1.2	< 1.3 (2H), typical < 1.15 n/a (4H)	n/a
	> 400 µJ pump	< 1.4 (2H)	< 1.4 (2H) < 1.5 (3H)	< 1.4 (2H) n/a (4H)	

[1] Depends on pump laser model.
[2] High energy versions are available, contact sales@lightcon.com for specifications.
[3] Maximum output power of 1 W.
[4] Maximum output power of 0.15 W.

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
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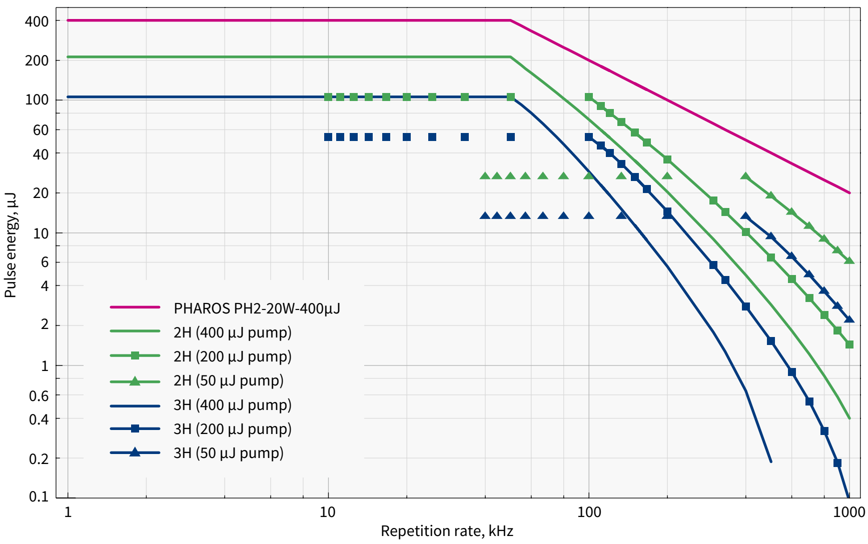
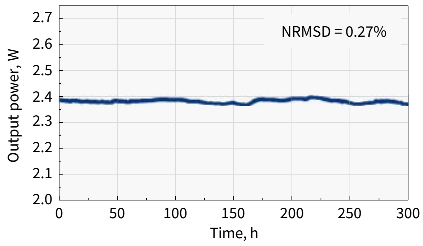
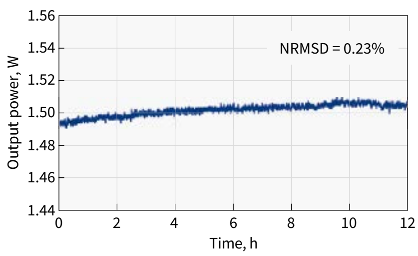


Pulse energy vs repetition rate of PHAROS with HG



3H output power stability



4H output power stability

LIGHT CONVERSION

BiBurst option

Tunable GHz and MHz Burst with Burst-in-Burst Capability

PHAROS and CARBIDE (CB3) lasers have an option for tunable GHz and MHz burst with burst-in-burst capability – called BiBurst.

In standard mode, a single pulse is emitted at some fixed frequency. In burst mode, the output consists of pulse packets instead of single pulses. Each packet consists of a certain number of equally separated pulses. MHz-Burst contains N pulses with a nanosecond period, GHz-Burst contains P pulses with a picosecond period. If both bursts are used, the equally separated pulse packets contain sub-packets of pulses (burst-in-burst, BiBurst).

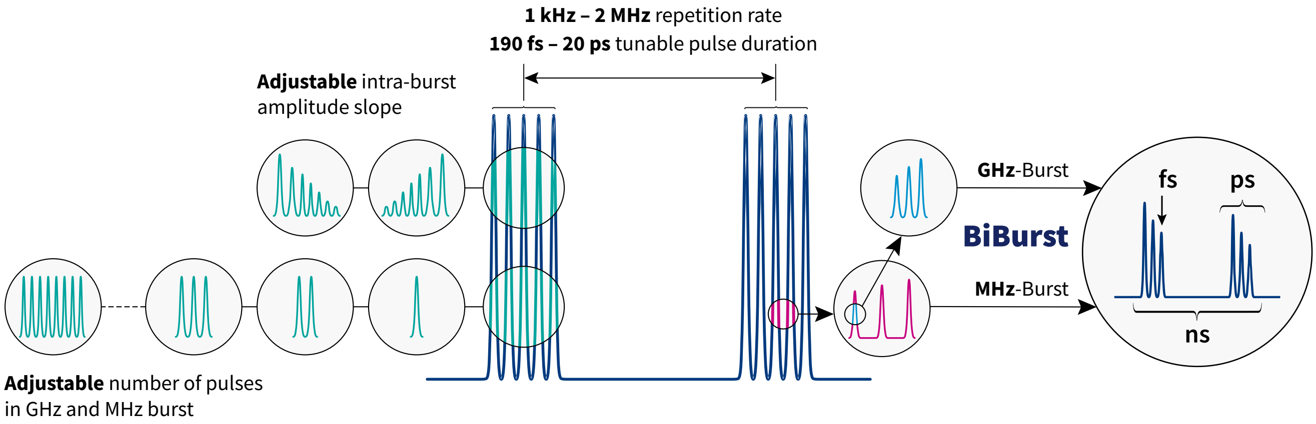
PHAROS and CARBIDE lasers with the BiBurst option bring new capabilities to high-tech manufacturing industries such as consumer electronics, integrated photonic chip manufacturing, future display manufacturing, and quantum technologies. The applications include:

- brittle material drilling and cutting
- deep engraving
- selective ablation
- volume modification of transparent materials
- hidden marking
- surface polishing
- surface functionalization

SPECIFICATIONS

Mode		CARBIDE-CB3	PHAROS
GHz-Burst	Intra burst pulse period [1]	440 ± 40 ps	200 ± 40 ps
	Number of pulses, P [2]	1 ... 10	1 ... 25
MHz-Burst	Intra burst pulse period	≈ 15 ns	
	Number of pulses, N	1 ... 10	1 ... 9 (7 with FEC)

[1] *Custom spacing is available on request.*
[2] *Maximum number of pulses in a burst depends on the laser repetition rate. Custom number of pulses is available on request.*



CARBIDE

Unibody-Design Industrial-Grade Femtosecond Lasers

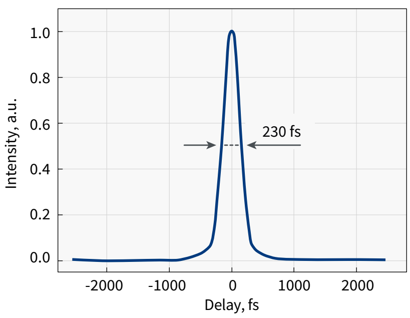
FEATURES

- 190 fs – 20 ps tunable pulse duration
- 800 µJ maximum pulse energy
- 80 W maximum output power
- Single-shot – 2 MHz repetition rate
- Pulse picker for pulse-on-demand mode
- Industrial-grade design
- Air- or water-cooled models
- Optional automated harmonic generator
- Optional scientific interface module

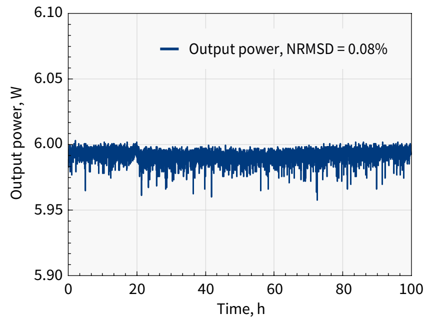
CARBIDE-CB3

CARBIDE is a series of femtosecond lasers combining high average power and excellent power stability. CARBIDE features market-leading output parameters without compromises to beam quality and stability. A compact and robust optomechanical CARBIDE design allows a variety of applications in top-class research centers, as well as display, automotive, LED, medical, and other industries. The reliability of CARBIDE has been proven by hundreds of systems operating 24/7 in the industrial environment.

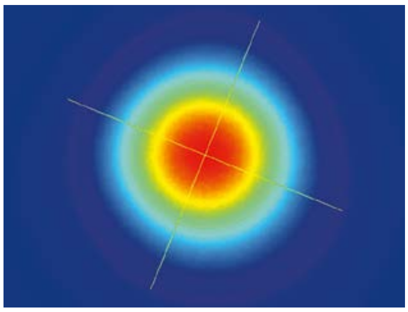
The tunability of CARBIDE lasers enables our customers to discover the most efficient manufacturing processes. Tunable parameters include pulse duration (190 fs – 20 ps), repetition rate (single-shot – 2 MHz), pulse energy (up to 0.8 mJ), and average power (up to 80 W). A pulse-on-demand mode is available using the built-in pulse picker. The CARBIDE lasers can be equipped with industrial-grade modules.



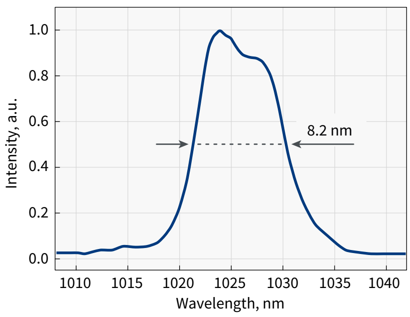
Typical pulse duration of CARBIDE laser



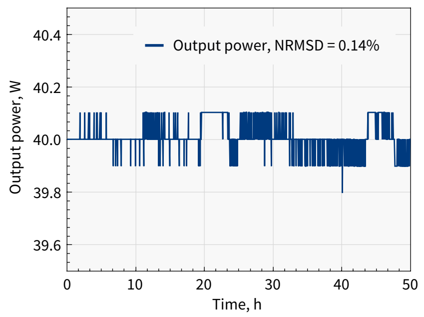
Long-term power stability of CARBIDE-CB5



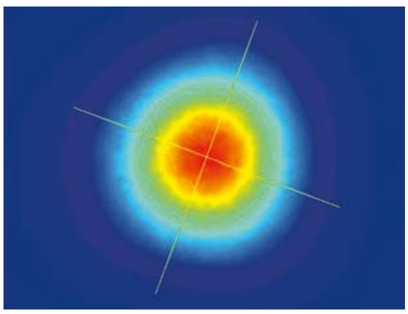
Typical beam profile of CARBIDE-CB5



Typical spectrum of CARBIDE laser



Long term power stability of CARBIDE-CB3



Typical beam profile of CARBIDE-CB3

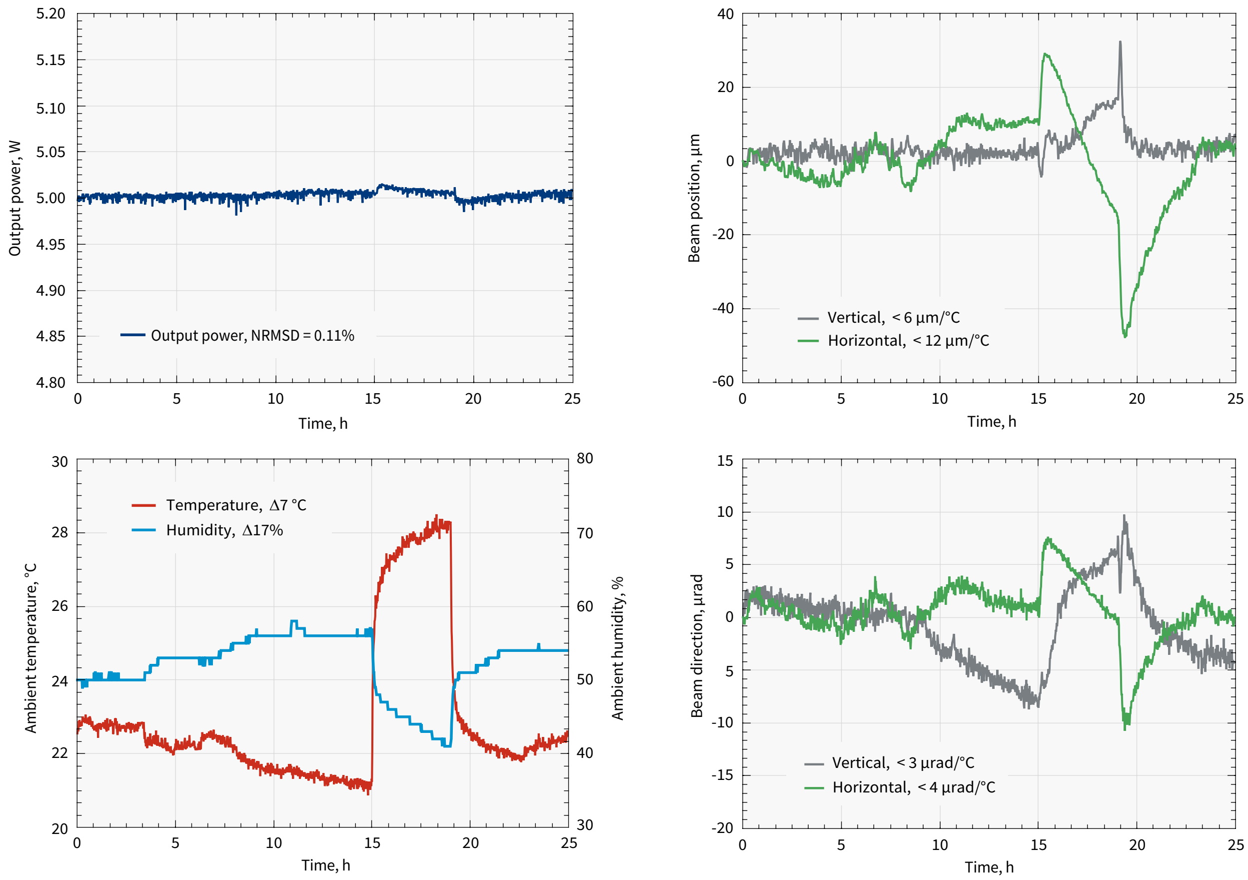
SPECIFICATIONS

Model	CB3-20W (NEW)	CB3-40W	CB3-80W	CB5		CB5-SP
OUTPUT CHARACTERISTICS						
Cooling method	Water-cooled			Air-cooled [1]		
Maximum output power	20 W	40 W	80 W	6 W	5 W	
Pulse duration [2]	< 250 fs			< 290 fs		< 190 fs
Pulse duration tuning range	250 fs – 10 ps			290 fs – 20 ps		190 fs – 20 ps
Maximum pulse energy	0.4 mJ		0.8 mJ	100 µJ	83 µJ	100 µJ
Repetition rate	Single-shot – 1 MHz	Single-shot – 1 MHz (2 MHz on request)	Single-shot – 2 MHz	Single-shot – 1 MHz		
Pulse selection	Single-shot, pulse-on-demand, any fundamental repetition rate division					
Center wavelength [3]	1030 ± 10 nm					
Polarization	Linear, horizontal; 1 : 1000			Linear, vertical; 1 : 1000		
Beam quality	TEM_{00}; $M^2 < 1.2$					
Beam diameter [4]	2.5 mm		2.7 mm	1.4 mm		1.5 mm
Pulse-to-pulse energy stability [5]	RMS deviation [6] < 0.5% over 24 h					
Long-term power stability	RMS deviation [6] < 0.5% over 100 h					
Beam pointing stability	< 20 µrad/°C					
Pulse picker	FEC [7]			included	included [8]	included
Pulse picker leakage	< 0.5%			< 2%	< 0.1%	< 2%
OPTIONAL EXTENSIONS						
Harmonic generators	Integrated, optional *(see page 14)*					
Output wavelength	515 nm, 343 nm, or 257 nm					
Optical parametric amplifier	Integrated, optional *(see page 15)*					
Tuning range	320 – 10000 nm					
BiBurst option	Tunable GHz and MHz burst with burst-in-burst capability, optional *(see page 9)*			n/a		
GHz-Burst						
Intra burst pulse period [9]	440 ± 40 ps					
Number of pulses, P [10]	1 … 10					
MHz-Burst						
Intra burst pulse period	≈ 15 ns					
Number of pulses, N	1 … 10					
PHYSICAL DIMENSIONS						
Laser head (L × W × H)	632 × 305 × 173 mm			631 × 324 × 167 mm		
Chiller (L × W × H)	680 × 484 × 307 mm			Not required		
24 V DC power supply (L × W × H)	280 × 144 × 49 mm		320 × 200 × 75 mm	220 × 95 × 46 mm		
ENVIRONMENTAL & UTILITY REQUIREMENTS						
Operating temperature	15 – 30 °C (59 – 86 °F)			17 – 27 °C (62 – 80 °F)		
Relative humidity	< 80% (non-condensing)					
Electrical requirements	110 – 220 V AC, 50 – 60 Hz					
Rated power	600 W		1000 W	300 W		
Power consumption	500 W		700 W	150 W		
Electrical requirements (chiller)	100 – 230 V AC, 50 – 60 Hz		200 – 230 V AC, 50 – 60 Hz	Not required		
Rated power (chiller)	1400 W		2000 W			
Power consumption (chiller)	1000 W		1300 W			

1) Water-cooled version available on request.
2) Assuming Gaussian pulse shape.
3) Precise wavelengths for specific models available upon request.
4) FWHM, measured at laser output, using maximum pulse energy.
5) Under stable environmental conditions.
6) Normalized to average pulse energy, NRMSD.
7) Provides fast energy control; external analog control input available. Response time – next available RA pulse.
8) Enhanced contrast AOM. Provides fast amplitude control of output pulse train.
9) Custom spacing is available on request.
10) Maximum number of pulses in a burst depends on the laser repetition rate. Custom number of pulses is available on request.

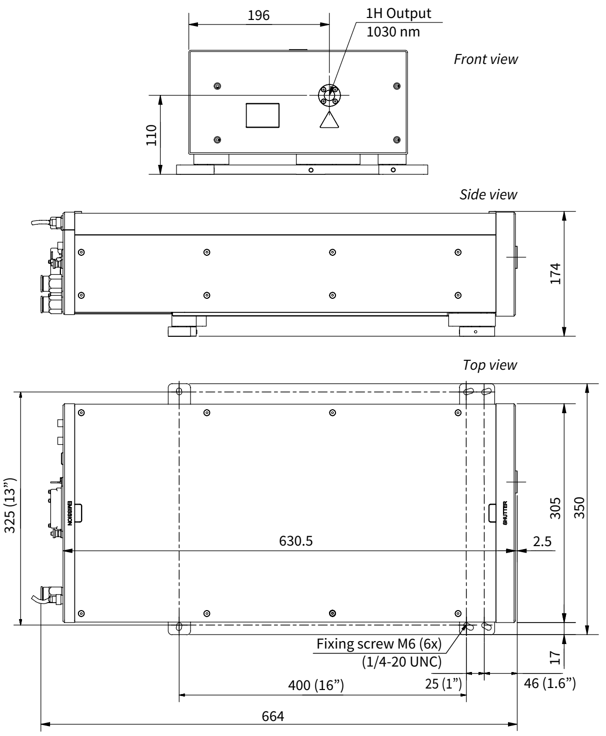
DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

STABILITY MEASUREMENTS

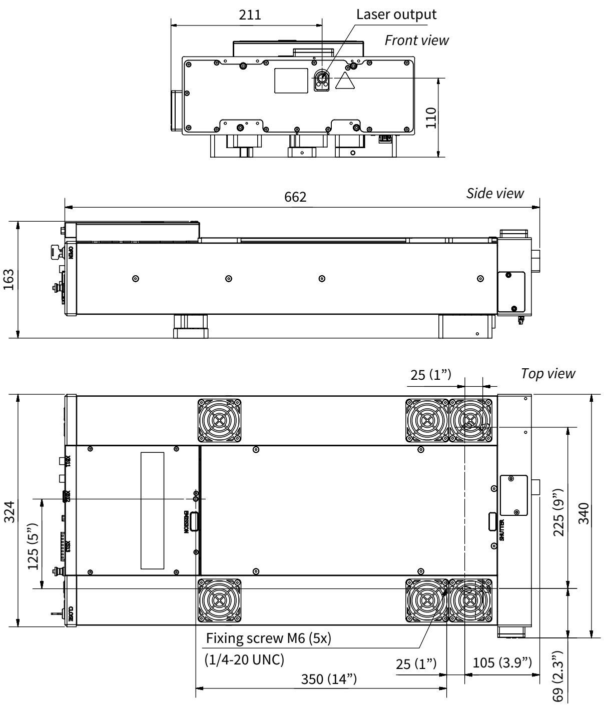


Output power, beam direction, and beam position of CARBIDE-CB5 under harsh environmental conditions

DRAWINGS



Drawing of CARBIDE-CB3



Drawing of air-cooled CARBIDE-CB5 with attenuator

SCI-M | CARBIDE

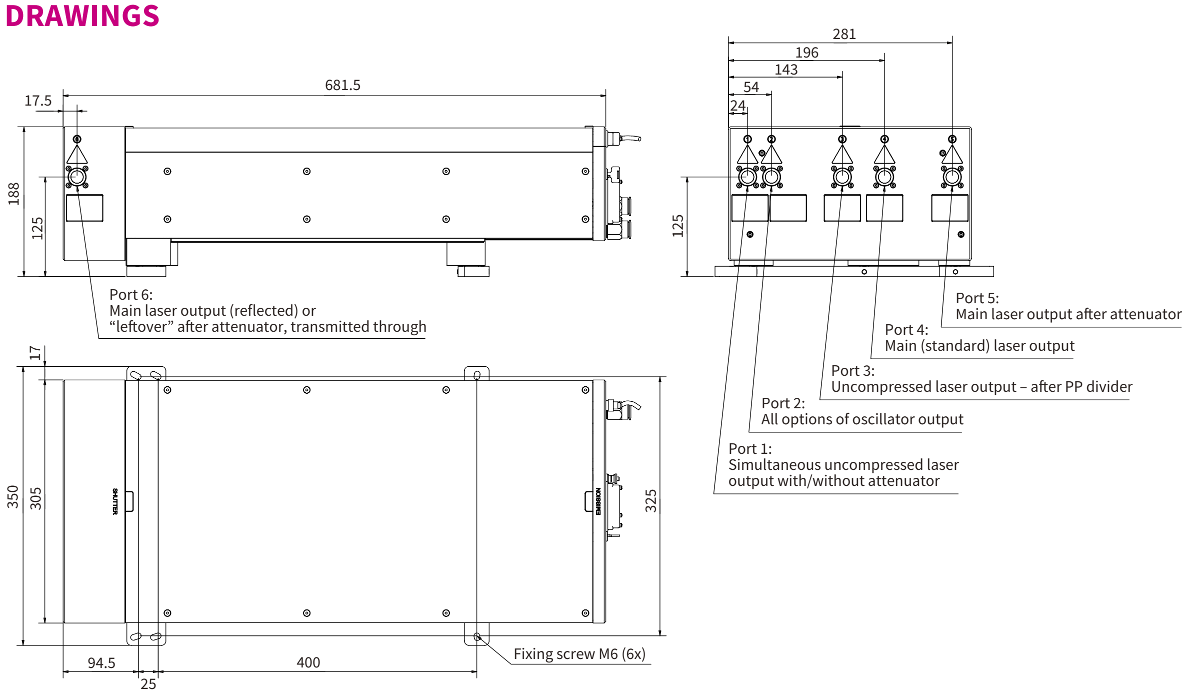
Scientific Interface Module for CARBIDE

FEATURES

- Simultaneous or separate oscillator output
- Uncompressed laser output
- Seeding by an external oscillator
- Beam-splitting options

The CARBIDE scientific interface module extends the versatility of the industrial-grade laser and makes it particularly attractive to scientific applications. This module incorporates multiple options such as a simultaneous or separate oscillator output, a second compressed or uncompressed laser output, and seeding by an external oscillator. For example, using it, the CARBIDE laser can be seeded by an oscillator from another CARBIDE laser, thus ensuring a precise optical synchronization between the two lasers. All the aforementioned outputs can be equipped with automated power attenuators. All options are compatible in between.

DRAWINGS



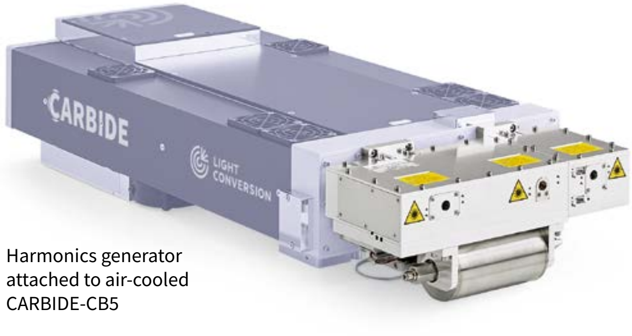
Drawing of CARBIDE-CB3-40-200 with scientific interface module

HG | CARBIDE

Automated Harmonic Generators

FEATURES

- 515 nm, 343 nm, or 257 nm output
- Automated harmonic selection
- Mounted directly on the laser head
- Industrial-grade design
- 30 W UV model option



Harmonics generator attached to air-cooled CARBIDE-CB5

CARBIDE lasers equipped with automated harmonic generators (HGs) provide a selection of fundamental (1030 nm), second (515 nm), third (343 nm), or fourth (257 nm) harmonic outputs using software control.

HGs are perfect for industrial applications that require a single-wavelength output. Modules, mounted directly at the output of the laser, are fully integrated into the system.

SPECIFICATIONS

Model		2H	2H-3H	2H-4H	CBM03-30W [1] NEW
Output wavelength [2] (automated selection)		1030 nm 515 nm	1030 nm 515 nm 343 nm	1030 nm 515 nm 257 nm	1030 nm 515 nm **343 nm**
Pump pulse energy		20 – 800 µJ	50 – 800 µJ	20 – 800 µJ	< 270 µJ
Pump pulse duration		< 300 fs			≈ 500 fs
Conversion efficiency / Output power		> 50% (2H)	> 50% (2H) > 25% (3H)	> 50% (2H) > 10% (4H) [3]	40 W (2H) 30 W (3H)
Beam quality (M²)	≤ 400 µJ pump	< 1.3 (2H), typical < 1.15	< 1.3 (2H), typical < 1.15 < 1.4 (3H), typical < 1.2	< 1.3 (2H), typical < 1.15 n/a (4H)	< 1.3 (2H, 3H)
	> 400 µJ pump	<1.4 (2H)	<1.4 (2H) <1.5 (3H)	<1.4 (2H) n/a (4H)	n/a

[1] Available only for CARBIDE-CB3-80W with maximum output power; has 1 year lifetime.
[2] Depends on pump laser model.
[3] Maximum output power of 1 W.

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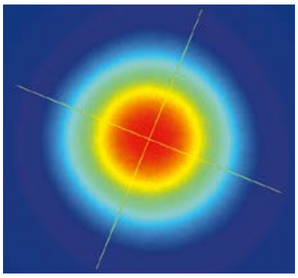
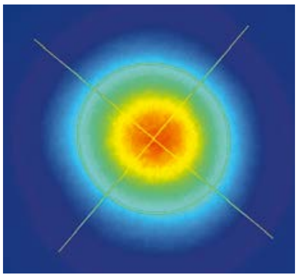
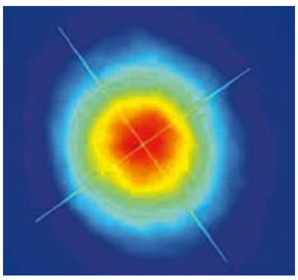


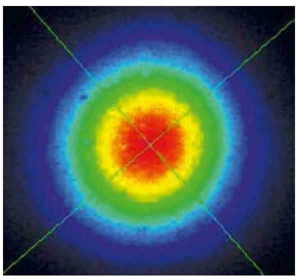
Typical 1H beam profile of CARBIDE-CB5 (60 kHz, 5 W)



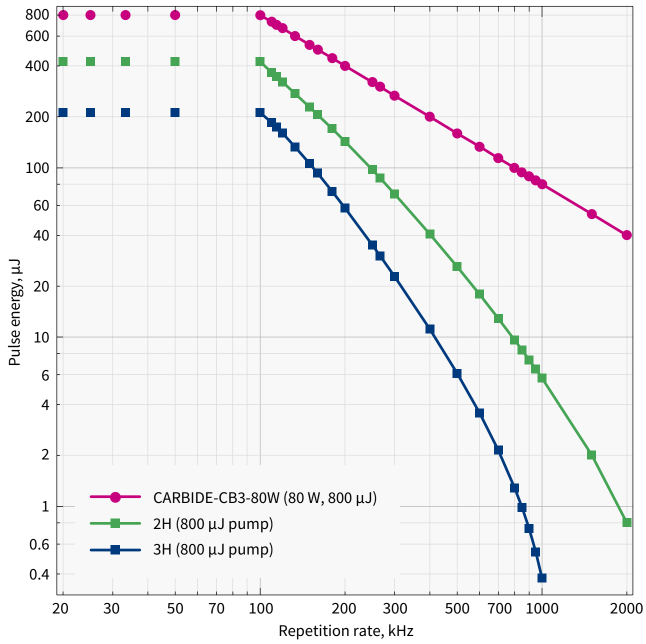
Typical 2H beam profile of CARBIDE-CB5 (100 kHz, 3.4 W)



Typical 3H beam profile of CARBIDE-CB5 (100 kHz, 2.2 W)



Typical 4H beam profile of CARBIDE-CB5 (100 kHz, 100 mW)



Pulse energy vs repetition rate of CARBIDE-CB3-80W with HG

LIGHT CONVERSION

I-OPA

Industrial-Grade Optical Parametric Amplifier

FEATURES

- Tunable or fixed wavelength options
- Industrial-grade design
- Plug-and-play installation and user-friendly operation
- Single-shot – 2 MHz repetition rate
- Up to 40 W pump power
- < 100 fs pulse duration option
- Integrated tunable beam splitter for pump laser beam

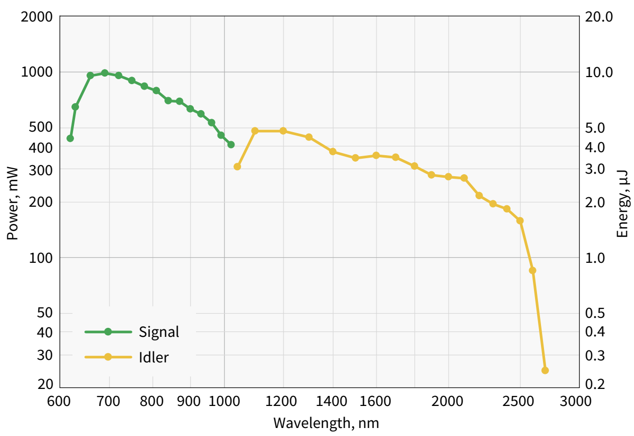
I-OPA-TW attached to air-cooled CARBIDE-CB5

The industrial-grade optical parametric amplifier I-OPA series marks a new era of simplicity in the world of tunable wavelength femtosecond light sources. Based on over 10 years of experience producing the ORPHEUS series of optical parametric amplifiers, this solution brings together the tunability of wavelength with the robust industrial-grade design. The I-OPA is a rugged module attachable to our PHAROS and CARBIDE lasers, providing long-term stability comparable to that of the industrial-grade harmonic generators.

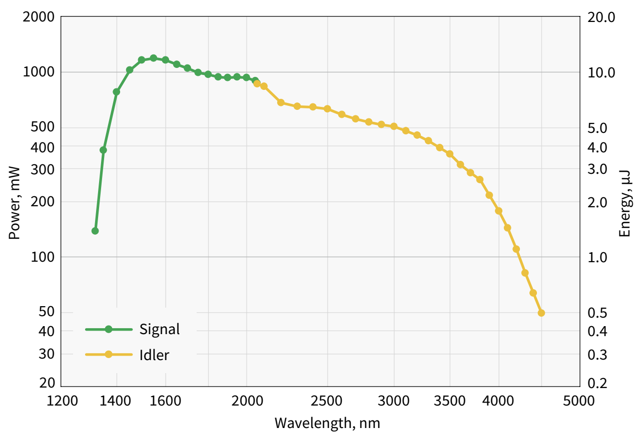
The tunable-wavelength I-OPA (I-OPA-TW) provides a wide tuning range and is primarily intended for spectroscopy and microscopy applications. In particular, the -HP model is targeted to be coupled with our HARPIA spectroscopy system as a pump beam source for ultrafast pump-probe spectroscopy. The -F model is primarily designed as a light source for multiphoton microscopy, the -ONE model – for IR spectroscopy and other applications where high energy mid-IR pulses are desired. All of the models can also be used for micromachining and other industrial applications.

The fixed-wavelength I-OPA (I-OPA-FW) is primarily intended for applications that desire a single-wavelength output. The industrial-grade design provides mechanical stability and eliminates the effects of air-turbulence, minimizing energy fluctuations and ensuring stable long-term performance.

The I-OPA-TW is best suited for R&D systems, while the I-OPA-FW is a cost-effective solution for large-scale production.



Typical I-OPA-TW-HP tuning curves.
Pump: 10 W, 100 µJ, 100 kHz



Typical I-OPA-TW-ONE tuning curves.
Pump: 10 W, 100 µJ, 100 kHz

SPECIFICATIONS OF TUNABLE I-OPA

Model	I-OPA-TW-HP	I-OPA-TW-F	I-OPA-TW-ONE
Based on ORPHEUS model	ORPHEUS	ORPHEUS-F	ORPHEUS-ONE
Pump power	Up to 40 W		
Pump pulse energy	10 – 400 µJ		20 – 400 µJ
Repetition rate	Up to 2 MHz		
Tuning range, Signal	640 – 1010 nm	650 – 900 nm	1350 – 2060 nm
Tuning range, Idler	1050 – 2600 nm	1200 – 2500 nm	2060 – 4500 nm
Conversion efficiency at peak	> 7% @ 700 nm (40 – 400 µJ pump; up to 1 MHz)		> 9% @ 1550 nm (40 – 400 µJ pump; up to 1 MHz)
	> 3.5% @ 700 nm (10 – 40 µJ pump; up to 2 MHz)		> 6% @ 1550 nm (20 – 40 µJ pump; up to 2 MHz)
Long-term power stability (8 h)	< 1.5% @ 800 nm		< 1.5% @ 1550 nm
Pulse energy stability (1 min)	< 1.5% @ 800 nm		< 1.5% @ 1550 nm
Additional options	n/a	SCMP (Signal pulse compressor) ICMP (Idler pulse compressor) PCMP (pre-chirp dispersion compensator)	n/a
Spectral bandwidth [1]	80 – 220 cm^{-1} @ 700 – 960 nm	200 – 750 cm^{-1} @ 650 – 900 nm 150 – 500 cm^{-1} @ 1200 – 2000 nm	60 – 150 cm^{-1} @ 1450 – 2000 nm
Pulse duration [2]	120 – 250 fs	< 60 fs @ 800 – 900 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	100 – 300 fs
Optional wavelength extensions	SHS: 320 – 505 nm SHI: 525 – 640 nm Conversion efficiency 1.2% at peak	Contact sales@lightcon.com	DFG: 4500 – 10000 nm [3]
Applications	Micromachining Microscopy Spectroscopy	Nonlinear microscopy Ultrafast spectroscopy	Mid-IR spectroscopy AFM microscopy

[1] *I-OPA-TW-F outputs broad bandwidth pulses which are compressed externally.*
[2] *Output pulse duration depends on wavelength and pump laser pulse duration. I-OPA-TW-F requires pulse compressors to achieve short pulse duration.*
[3] *Up to 16 µm tuning range is accessible with external difference frequency generator (DFG).*

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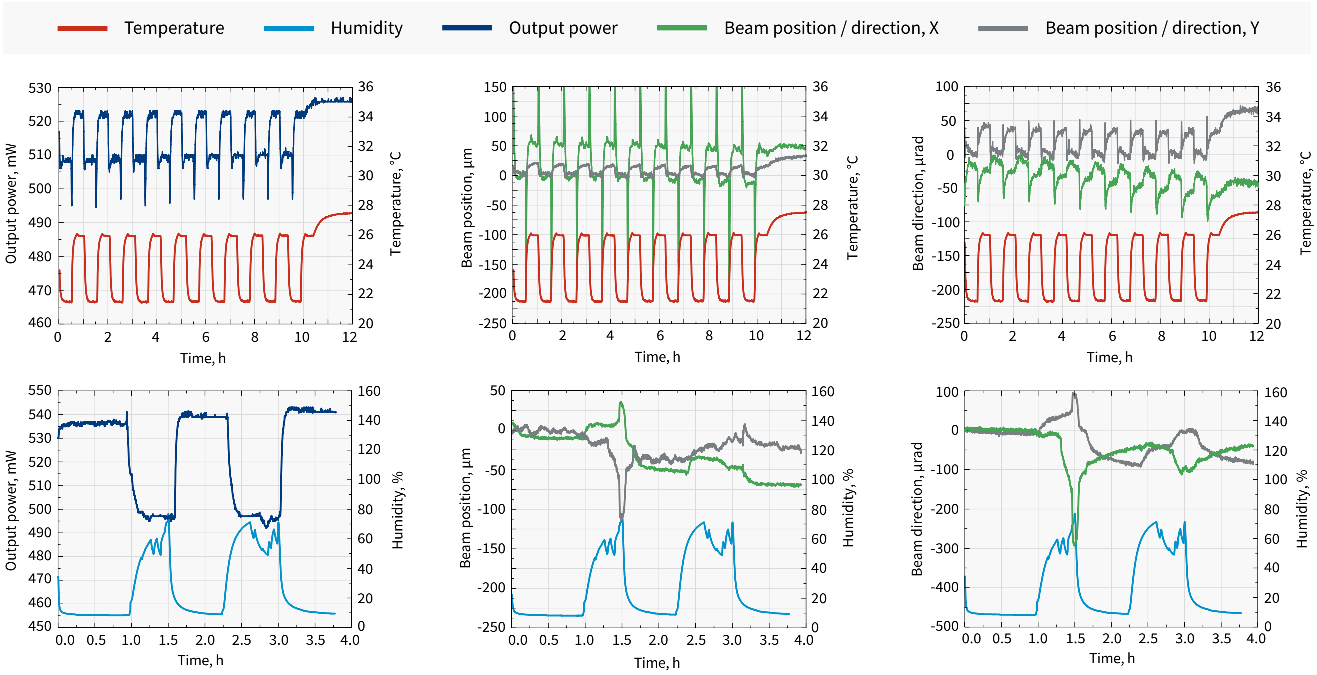
SPECIFICATIONS OF FIXED WAVELENGTH I-OPA

Model	I-OPA-FW-HP	I-OPA-FW-F	I-OPA-FW-ONE
Pump power	Up to 40 W		
Pump pulse energy	10 – 500 µJ		20 – 1000 µJ
Repetition rate	Up to 2 MHz		
Wavelength selection range, Signal [1]	640 – 1010 nm	650 – 900 nm	1350 – 2060 nm
Wavelength selection range, Idler [1]	1050 – 2600 nm	1200 – 2500 nm	2060 – 4500 nm
Conversion efficiency at peak	> 7% @ 700 nm (40 – 500 µJ pump; up to 1 MHz)		> 9% @ 1550 nm (40 – 1000 µJ pump; up to 1 MHz)
	> 3.5% @ 700 nm (10 – 40 µJ pump; up to 2 MHz)		> 6% @ 1550 nm (10 – 40 µJ pump; up to 2 MHz)
Long-term power stability (8 h)	< 1.5% @ 800 nm		< 1.5% @ 1550 nm
Pulse energy stability (1 min)	< 1.5% @ 800 nm		< 1.5% @ 1550 nm
Spectral bandwidth [2]	80 – 220 cm^{-1} @ 700 – 960 nm	200 – 750 cm^{-1} @ 650 – 900 nm 150 – 500 cm^{-1} @ 1200 – 2000 nm	60 – 150 cm^{-1} @ 1450 – 2000 nm
Pulse duration [3]	120 – 250 fs	< 60 fs @ 800 – 900 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	150 – 300 fs
Applications	Micromachining Microscopy Spectroscopy	Nonlinear microscopy Ultrafast spectroscopy	Micromachining Mid-IR generation

[1] *A single wavelength can be selected from the Signal/Idler range. Signal will have accessible Idler pair, and vice versa.*
[2] *I-OPA-FW-F outputs broad bandwidth pulses which are compressed externally.*
[3] *Output pulse duration depends on wavelength and pump laser pulse duration. I-OPA-FW-F requires external pulse compressors to achieve short pulse duration.*

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT



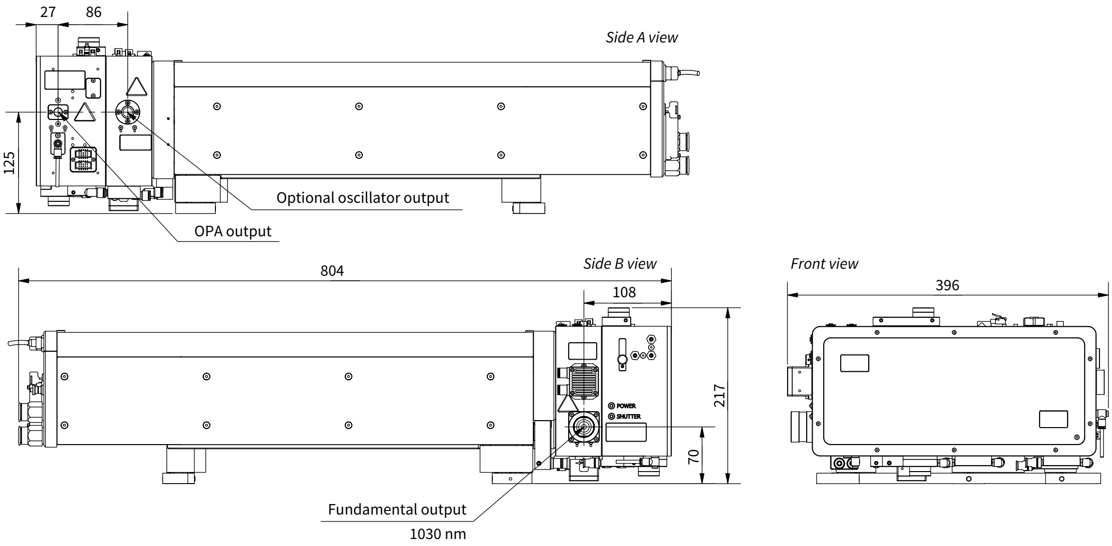
I-OPA-FW output power, beam position, and beam direction under harsh environmental conditions

COMPARISON WITH OTHER FEMTOSECOND AND PICOSECOND LASERS

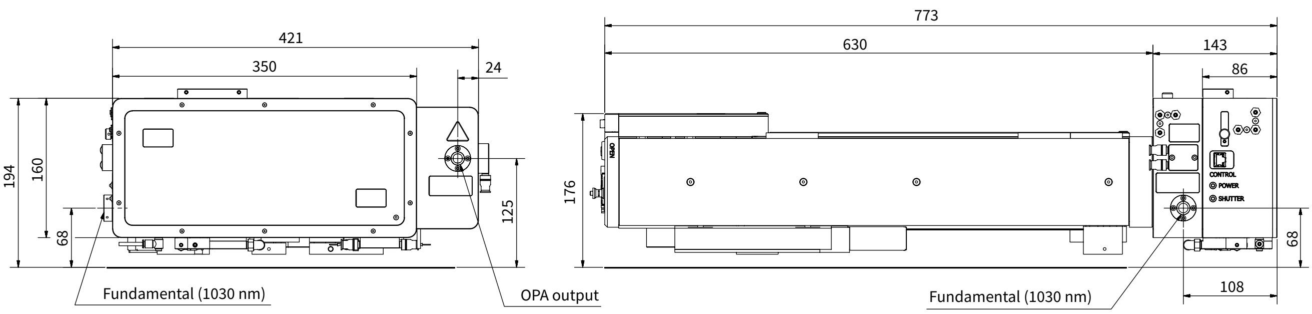
<table>
<tr><th>Laser technology</th><th>Our solution</th><th>HG or HIRO</th><th>I-OPA-FW-F</th><th>I-OPA-FW-ONE</th></tr>
<tr><td></td><td></td><td colspan="3">Pulse energy at 100 kHz, using PHAROS-10W laser</td></tr>
<tr><td>Excimer (193 nm, 213 nm)</td><td>5H of PHAROS (205 nm)</td><td>5 µJ</td><td rowspan="3">n/a</td><td rowspan="5">n/a</td></tr>
<tr><td>3H of Ti:Sapphire (266 nm)</td><td>4H of PHAROS (257 nm)</td><td>10 µJ</td></tr>
<tr><td>3H of Nd:YAG (355 nm)</td><td>3H of PHAROS (343 nm)</td><td>25 µJ</td></tr>
<tr><td>2H of Nd:YAG (532 nm)</td><td>2H of PHAROS (515 nm)</td><td>50 µJ</td><td>35 µJ</td></tr>
<tr><td>Ti:Sapphire (800 nm)</td><td>OPA output (750 – 850 nm)</td><td>n/a</td><td>10 µJ</td></tr>
<tr><td>Nd:YAG (1064 nm)</td><td>PHAROS output (1030 nm)</td><td colspan="3">100 µJ</td></tr>
<tr><td>Cr:Forsterite (1240 nm)</td><td>OPA output (1200 – 1300 nm)</td><td rowspan="4">n/a</td><td>5 µJ</td><td>n/a</td></tr>
<tr><td>Erbium (1560 nm)</td><td>OPA output (1500 – 1600 nm)</td><td>3 µJ</td><td>15 µJ</td></tr>
<tr><td>Thulium / Holmium (1.95 – 2.15 µm)</td><td>OPA output (1900 – 2200 nm)</td><td>2 µJ</td><td>10 µJ</td></tr>
<tr><td>Other sources (2.5 – 4.0 µm)</td><td>OPA output</td><td></td><td>1 – 5 µJ</td></tr>
</table>

Note that the pulse energy scales linearly in a broad range of pump parameters. For example, a PHAROS-PH2-20W laser at 50 kHz (400 µJ energy) will increase the output power twice, and the pulse energy 4 times compared to the reference table above. The pulse duration at the output is < 300 fs in all cases. The OPA output is not limited to these particular ranges of operation, it is continuously tunable as shown in tuning curves.

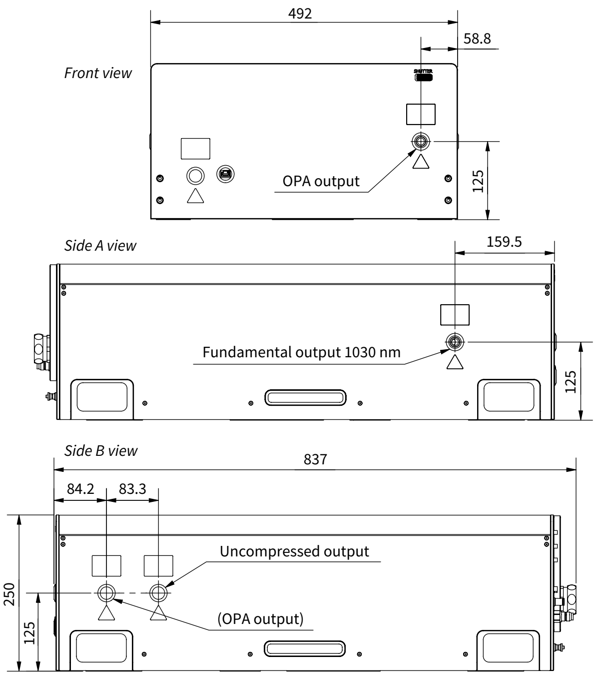
DRAWINGS



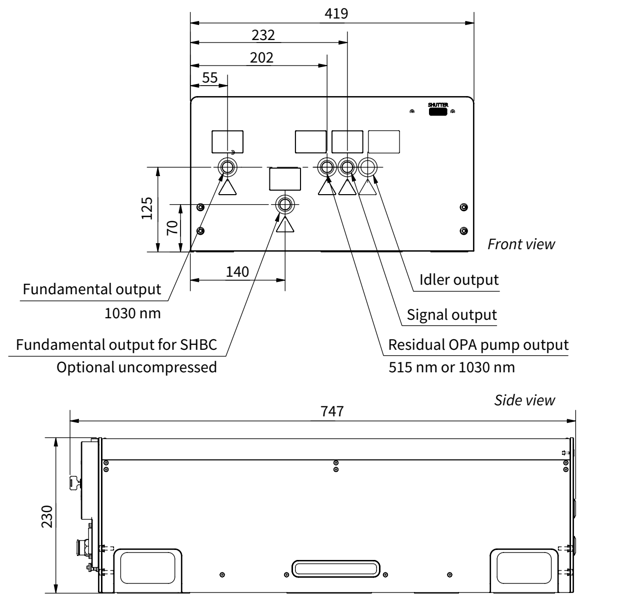
Drawing and output ports of CARBIDE-CB3 with tunable I-OPA-TW-HP



Drawing and output ports of CARBIDE-CB5 with tunable I-OPA-TW-HP



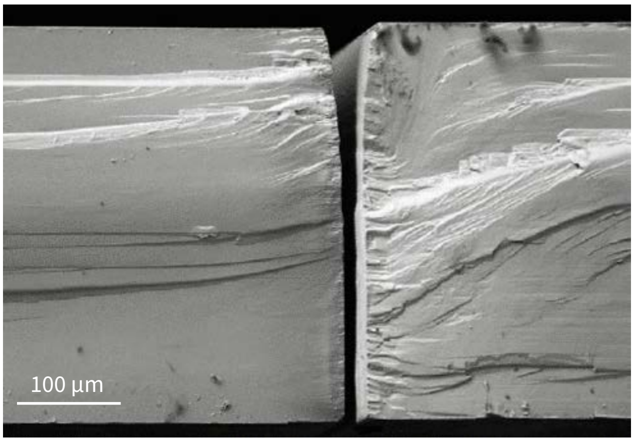
Drawing and output ports of PHAROS-PH2
with tunable I-OPA-TW-HP



Drawing and output ports of PHAROS-PH2
with fixed-wavelength I-OPA-FW-HP

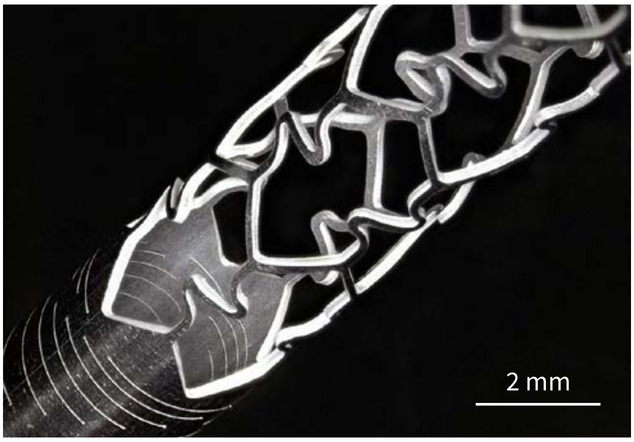
EXAMPLES OF INDUSTRIAL APPLICATIONS

Brittle & highly thermal-sensitive material cutting



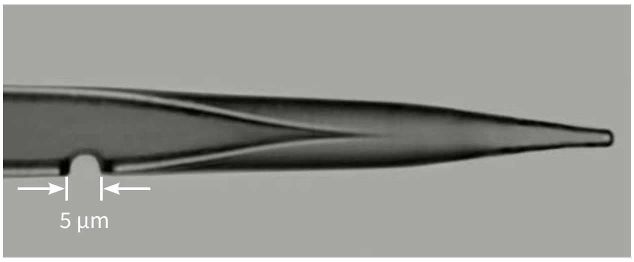
Multi-pass cadmium tungstate cutting.
No cracks. All thermal trace effects eliminated.
Source: Micronanics Laser Solutions Centre.

Stainless steel stent cutting



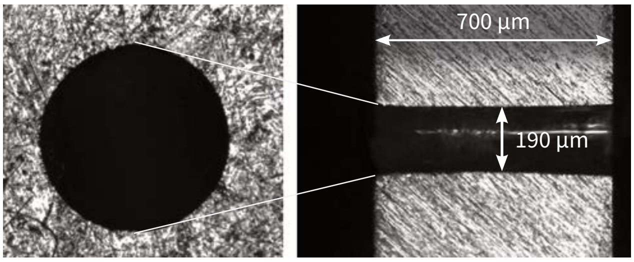
Stent cut using CARBIDE laser.
Source: Amada Miyachi America.

Glass needle microdrilling



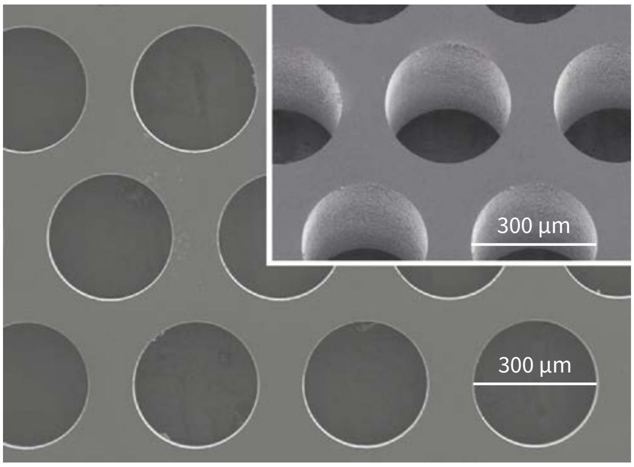
Glass needle microdrilling.
Source: Workshop of Photonics.

Steel drilling



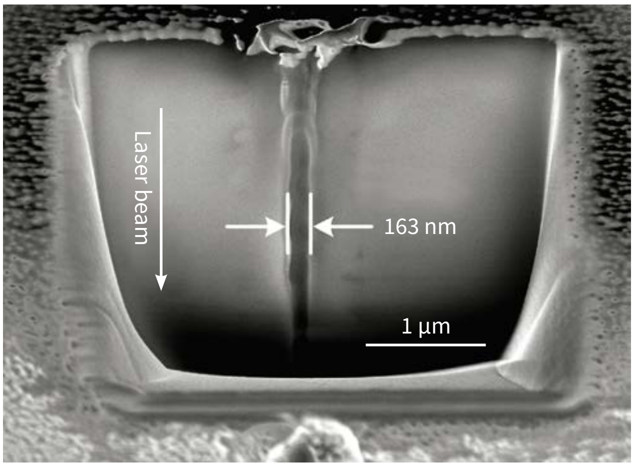
Taperless hole microdrilling in stainless steel alloys.
Source: Workshop of Photonics.

Various type glass drilling



Various glass drilling.
Source: Workshop of Photonics.

Nanodrilling of fused silica



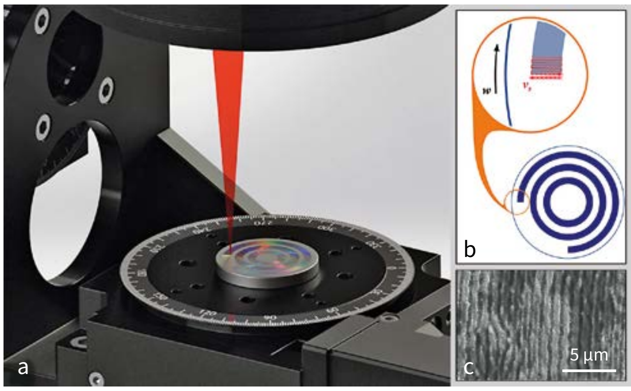
Longitudinal section of a single void.
Source: “Ultrashort Bessel beam photoinscription of Bragg grating waveguides and their application as temperature sensors”, G. Zhang, G. Cheng, M. Bhuyan, C. D’Amico, Y. Wang, R. Stoian. Photon. Res. (2019).

Milling of complex 3D surfaces

3D milled sample in copper. Zoom in SEM image.

Source: “Highly-efficient laser ablation of copper by bursts of ultrashort tuneable (fs-ps) pulses”, A.Žemaitis, P.Gečys, M.Barkauskas, G.Račiukaitis, M.Gedvilas. Scientific Reports (2019).

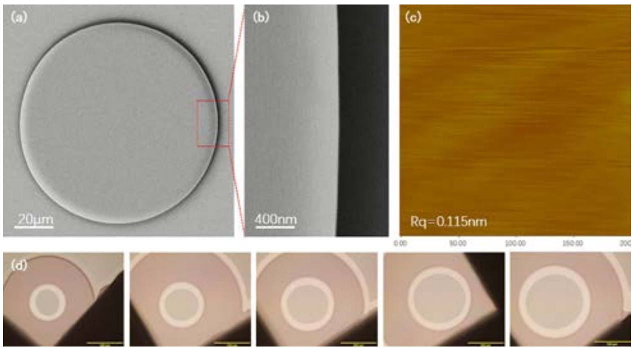
Friction and wear reduction



(a) Schematic of the laser treatment, (b) laser patterning strategy, (c) SEM image of induced LIPSS.

Source: “Tribological properties of high-speed uniform femtosecond laser patterning on stainless steel”, I.Gnilitskyi, A.Rota, E.Gualtieri, S.Valeri, L.Orazi. Lubricants (2019).

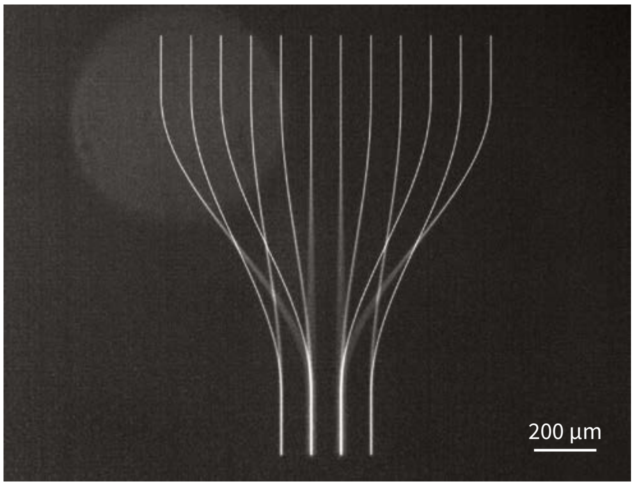
Selective Cr thin film ablation



Cr thin film ablation for creation of $LiNbO_3$ micro-disk resonator. (a,b) SEM images, (c) AFM image of micro-disk wedge, (d) optical images of micro-disk resonators with different diameters.

Source: “Fabrication of crystalline microresonators of high quality factors with a controllable wedge angle on lithium niobate on insulator”, J.Zhang, Z.Fang, J.Lin, J.Zhou, M.Wang, R.Wu, R.Gao, Y.Cheng. Nanomaterials (2019).

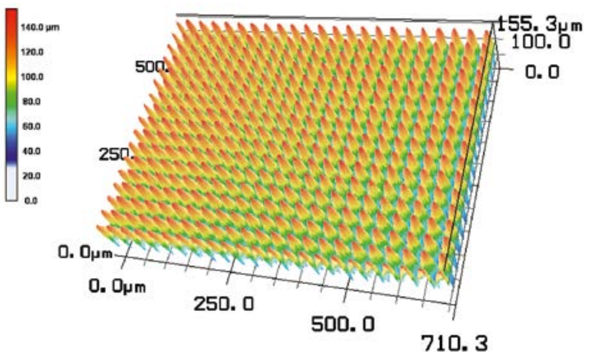
3D waveguides



3D waveguides fabricated in fused silica glass.

Source: Workshop of Photonics.

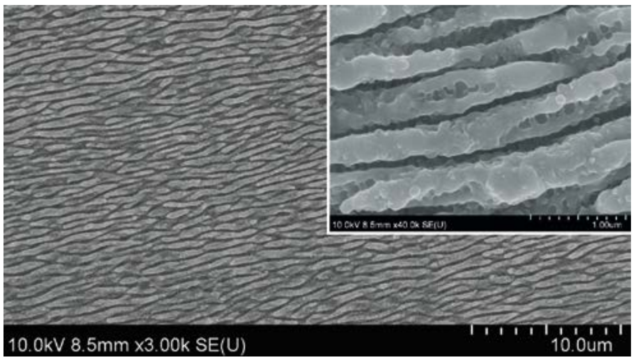
Terahertz broadband anti-reflection structures



Fabricated moth-eye 3D profile, taken by laser scanning microscope.

Source: “Terahertz broadband anti-reflection moth-eye structures fabricated by femtosecond laser processing”, H.Sakurai, N.Nemoto, K.Konishi, R.Takaku, Y.Sakurai, N.Katayama, T.Matsumura, J.Yumoto, M.Kuwata-Gonokami. OSA Continuum (2019).

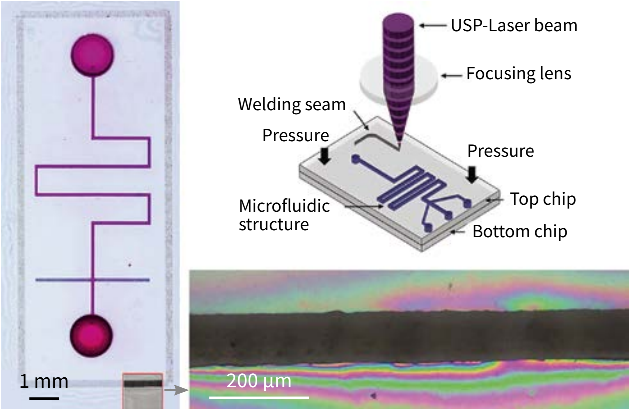
Surface-enhanced Raman scattering (SERS) sensors fabrication



SEM image of the Ti-6Al-4V (TC4) surface after irradiation with progressive laser scan.

Source: “Large-scale fabrication of nanostructure on bio-metallic substrate for surface enhanced Raman and fluorescence scattering”, L.Lu, J.Zhang, L.Jiao, Y.Guan. Nanomaterials (2019).

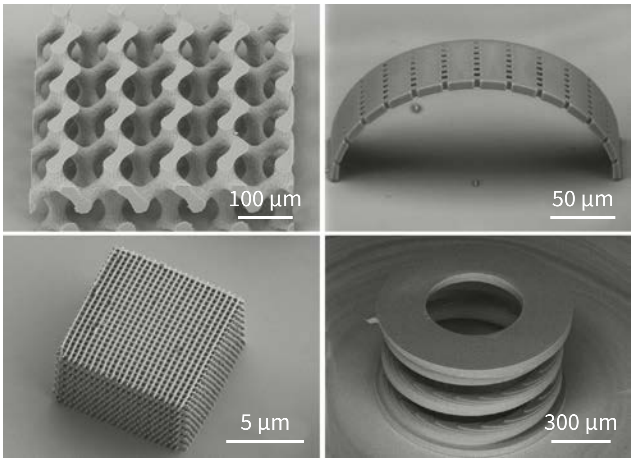
Lab-on-chip channel ablation and welding



Welding of transparent polymers for sealing of microfluidic devices. Top view on a sealed microfluidic device (left), welding seam (bottom right).

Source: “A new approach to seal polymer microfluidic devices using ultrashort laser pulses”, G. Roth, C. Esen and R. Hellmann. JLMN-Journal of Laser Micro/Nanoengineering (2019).

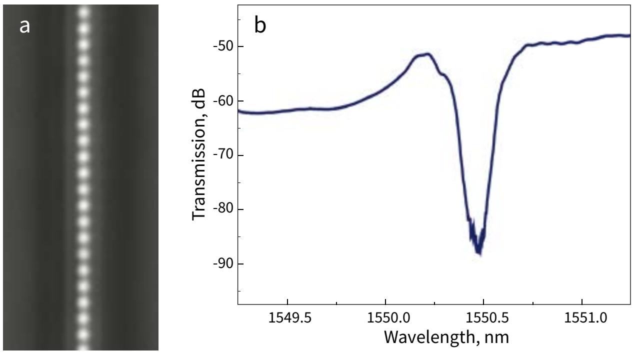
3D micro printing using multi-photon polymerization



Various 3D structures fabricated in SZ2080 polymer using multi-photon polymerization – nanophotonic devices, microoptics, micromechanics.

Source: Femtika.

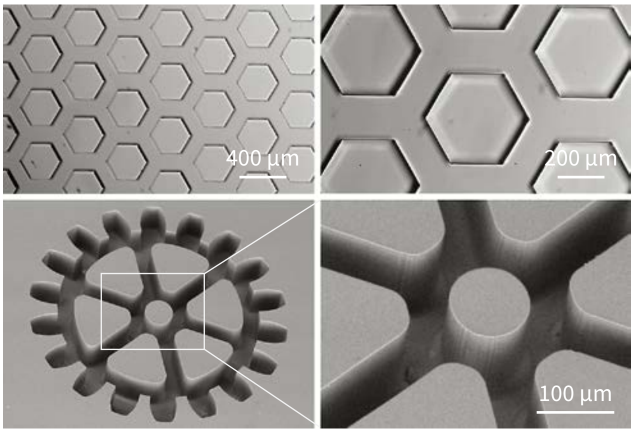
Bragg grating waveguide (BGW) writing



(a) First-order Bragg gratings inscribed in waveguide,
(b) Resonant spectral transmission of inscribed BGW.

Source: “Ultrashort Bessel beam photoinscription of Bragg grating waveguides and their application as temperature sensors”, G.Zhang, G. heng, M.Bhuyan, C.D’Amico, Y.Wang, R.Stoian. Photon. Res. (2019).

3D glass etching



Various structures fabricated in fused silica glass.

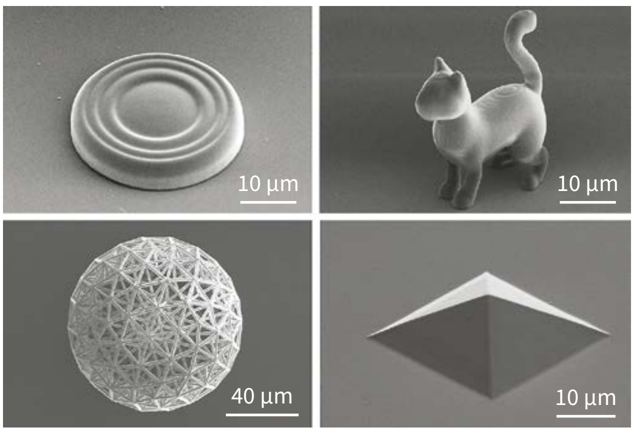
Source: Femtika.

Birefringent glass volume modifications

Form induced birefringence-retardance variation results in different colors in parallel polarized light.

Source: Workshop of Photonics.

3D multi-photon polymerization



Various 3D structures fabricated in SZ2080 polymer using multi-photon polymerization.

Source: Workshop of Photonics.

FLINT

Femtosecond Yb Oscillators

FEATURES

- < 40 fs pulse duration
- Up to 260 nJ pulse energy
- Up to 20 W output power
- 76 MHz repetition rate
- No amplified spontaneous emission
- Industrial-grade design
- Optional automated second harmonic generator
- Optional CEP stabilization
- Optional repetition rate locking to an external source

FLINT-FL2

FLINT oscillators are based on an Yb crystal pumped by a high-brightness laser diodes. Generation of femtosecond pulses is provided by Kerr lens mode-locking. Once started, mode-locking remains stable over a long period and is immune to minor mechanical impact. Oscillator cavity length can be adjusted using an optional piezo actuator. FLINT oscillators can also be equipped with carrier-envelope phase (CEP) stabilization and repetition rate locking to an external source.

SPECIFICATIONS

Model	FL1-02	FL1-08	FL1-SP	FL2-12	FL2-20	FL2-SP
Maximum output power	2 W	8 W	2 W [1]	12 W	20 W	2 W [1]
Pulse duration [2]	< 100 fs	< 120 fs	30 ... 50 fs [1]	< 120 fs	< 170 fs	30 ... 50 fs [1]
Maximum pulse energy [3]	26 nJ	105 nJ	26 nJ [1]	157 nJ	260 nJ	26 nJ [1]
Repetition rate	≈ 76 MHz [4]		≈ 76 MHz [5]	≈ 76 MHz		≈ 76 MHz [5]
Center wavelength	1035 [6] ± 10 nm	1030 ± 3 nm	1040 ± 10 nm	1029 ± 3 nm	1026 ± 2 nm	1040 ± 10 nm
Pulse-to-pulse energy stability [7]	RMS deviation [8] < 0.5% over 24 h					
Polarization	Linear, horizontal					
Beam quality	TEM_{00}; $M^2 < 1.2$					
Beam pointing stability	< 10 µrad/°C					
Internal 2H generator	n/a			Optional; conversion efficiency > 30%		
Internal attenuator	n/a			Yes		

PHYSICAL DIMENSIONS

Laser head (L × W × H)	430 × 195 × 114 mm	542 × 322 × 146 mm
Power supply and chiller rack (L × W × H)	642 × 553 × 540 mm	642 × 553 × 673 mm
Chiller	Different options available. Contact sales@lightcon.com	

ENVIRONMENTAL & UTILITY REQUIREMENTS

Operating temperature	15 – 30 °C (air conditioning recommended)		
Relative humidity	< 80% (non-condensing)		
Electrical requirements	110 V AC, 50 – 60 Hz, 2 A or 220 V AC, 50 – 60 Hz, 1 A		
Rated power	200 W		
Power consumption	100 W	150 W	
Power consumption (chiller)	200 W	800 W	200 W

[1] Maximum output power and pulse energy depends on the chosen pulse duration, e.g., < 50 fs – 2 W, 26 nJ, < 40 fs – 1 W, 13 nJ.
[2] Assuming Gaussian pulse shape.
[3] Depends on repetition rate. Approximate values are given for 76 MHz repetition rate.
[4] Other repetition rates are available in the range from 60 to 100 MHz.
[5] Other repetition rates are available in the range from 70 to 80 MHz.
[6] Choice of a particular central wavelength with ±1 nm tolerance is available upon request.
[7] With enabled power-lock, under stable environment.
[8] Normalized to average pulse energy, NRMSD.

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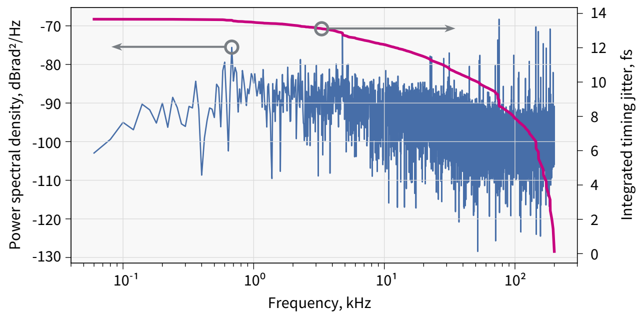
CEP STABILIZATION

FLINT oscillators can be equipped with feedback electronics for carrier-envelope phase (CEP) stabilization of the output pulses. The carrier-envelope offset (CEO) of the oscillator is actively locked to 1/4th of the repetition rate with a <100 mrad standard deviation.

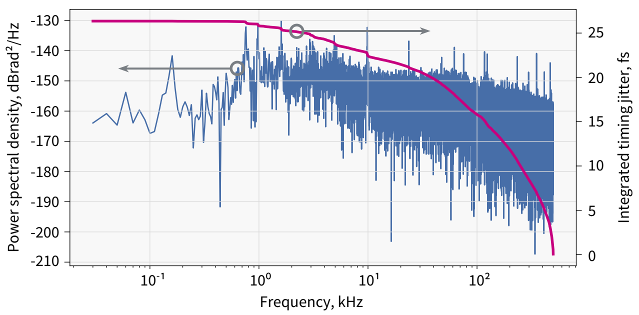


Phase noise data of CEP locked FLINT oscillator

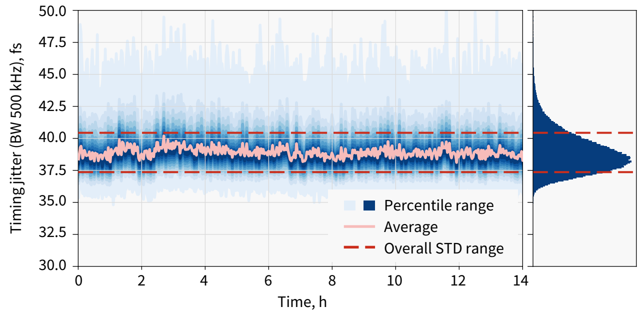
REPETITION RATE LOCKING

FLINT oscillators are customizable for repetition rate locking applications. Coupled with the necessary feedback electronics, the repetition rate can be synchronized to an external RF source using the two piezo stages installed inside the cavity.

The repetition rate locking system can assure an integrated timing jitter of less than 200 fs for RF reference frequencies larger than 500 MHz. Continuous phase shifting is available on request.

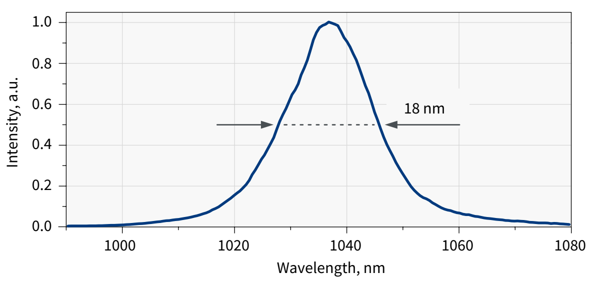


Phase noise data of FLINT oscillator locked to a 2.8 GHz RF source

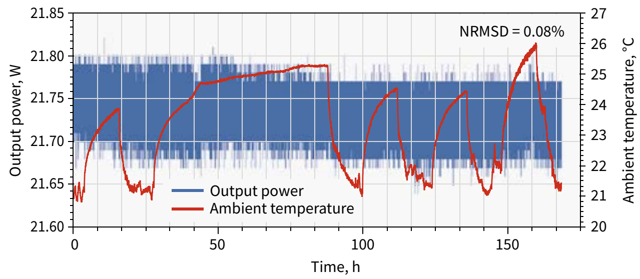


Timing jitter stability over 14 h;
FLINT oscillator locked to a 2.8 GHz RF source

PERFORMANCE

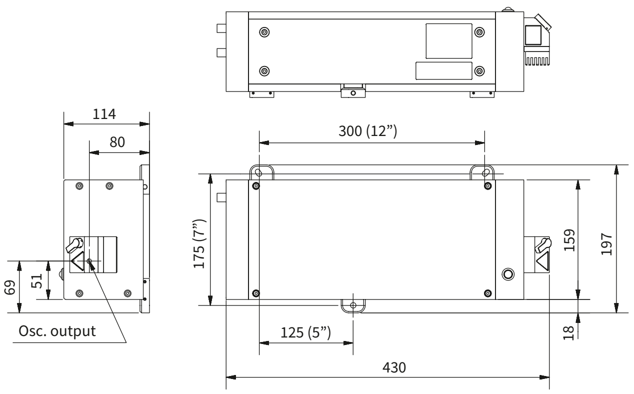


Typical FLINT optical spectrum

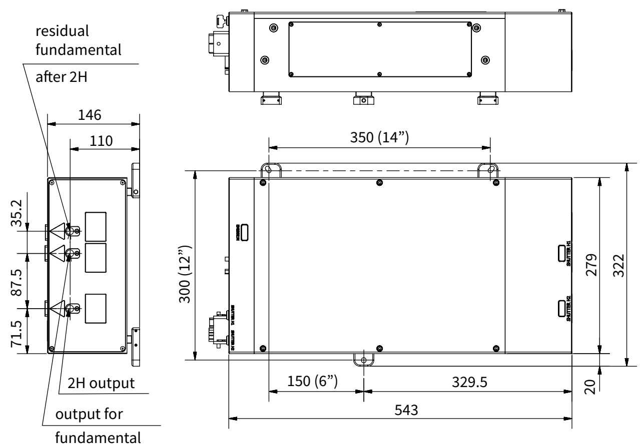


FLINT-FL2-20 (20 W) output power stability under harsh environmental conditions

DRAWINGS



FLINT-FL1 drawing



FLINT-FL2 drawing

HIRO

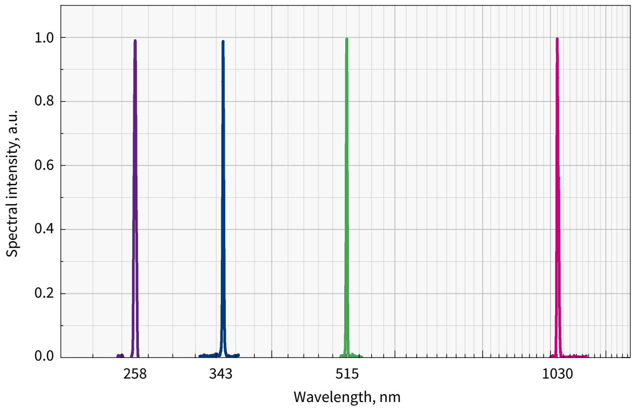
Customizable Harmonic Generator

FEATURES

- 515 nm, 343 nm, and 257 nm outputs
- Simple selection of active harmonic
- Simultaneous or switchable outputs
- Customizable for additional options

HIRO is a customizable free-standing harmonic generator for PHAROS and CARBIDE lasers, and FLINT oscillators. It provides a high power harmonic radiation at 515, 343, and 258 nm wavelengths. The selection of an active harmonic is manual but requires less than a few seconds thanks to its unique optomechanical design.

HIRO can be customized for additional options such as beam size and collimation adjustment, white light continuum generation, as well as beam division and harmonics splitting, which makes all harmonics available at the same time.



HIRO output wavelengths

SPECIFICATIONS (pumped by PHAROS or CARBIDE lasers)

Model	PH1F1	PH1F2	PH1F3	PH1F4	PH_W1	Output polarization
Available outputs [1) 2)]	2H (515 nm)	2H (515 nm) 4H (258 nm)	2H (515 nm) 3H (343 nm)	2H (515 nm) 3H (343 nm) 4H (258 nm)	any combination and white light continuum	
Conversion efficiency of 2H [3)]	> 50%		> 50% [4)]			H (V [5)])
Conversion efficiency of 3H [3)]	n/a		> 25%			V (H [5)])
Conversion efficiency of 4H [3)]	> 10%		> 10% [4) 6)]			V (H [5)])

PHYSICAL DIMENSIONS

Housing (L × W × H)	455 × 160 × 85 mm
Recommended area for fixing (L × W)	425 × 255 mm
Beam steering/intercepting (L × W × H)	150 × 55 × 75 mm

1) Depends on pump laser model.
2) Residual fundamental radiation available on request.
3) Percentage of the input pump power/energy when the repetition rate is up to 200 kHz.
4) When the third harmonic is not in use.
5) Optional, available on request.
6) Maximum output power of 1 W.

HIRO pumped with ps pulses available on request.

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SPECIFICATIONS (pumped by FLINT oscillators)

Generated harmonics	2H	3H	4H
Output wavelength	≈ 517 nm	≈ 345 nm	≈ 258 nm
Conversion efficiency	> 35%	> 5%	> 1%

PHYSICAL DIMENSIONS

Housing (L × W × H)	455 × 160 × 85 mm
Recommended area for fixing (L × W)	425 × 255 mm
Beam steering/intercepting (L × W × H)	150 × 55 × 75 mm

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
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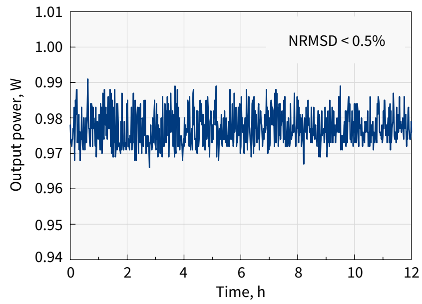
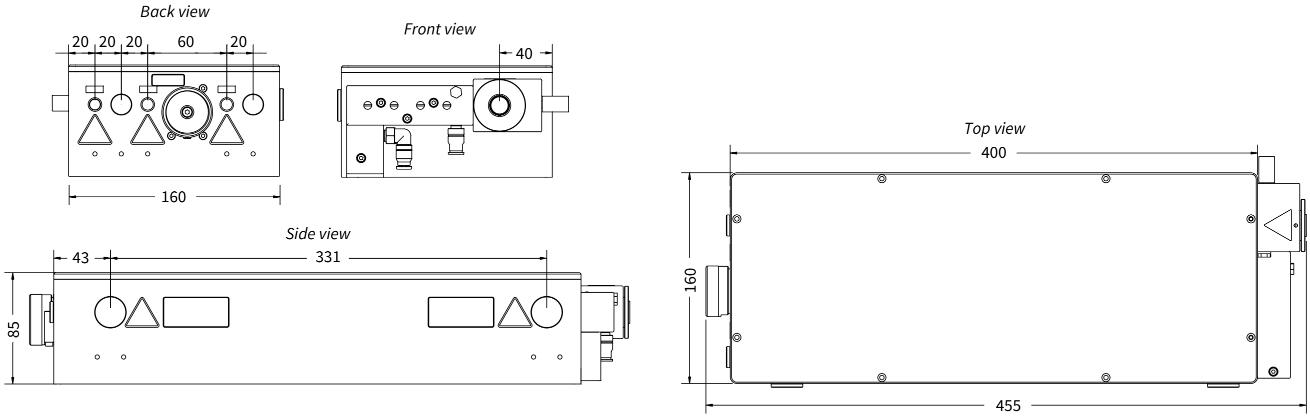


4H output power stability

DRAWINGS



Drawings of HIRO with water-cooling

SHBC

Second Harmonic Bandwidth Compressor

FEATURES

- 515 nm output
- < 10 cm^{-1} spectral bandwidth
- 2 – 4 ps pulse duration
- > 30% conversion efficiency
- Used to pump ORPHEUS-PS
- Small footprint

SHBC is a second harmonic bandwidth compressor dedicated to the generation of narrow-bandwidth picosecond pulses from a broad-bandwidth output of PHAROS and CARBIDE femtosecond lasers.

SHBC enables the creation of versatile optical setups which use fixed-wavelength or tunable narrow-bandwidth picosecond pulses in combination with tunable-wavelength broadband femtosecond pulses. In particular, such setups are of interest in sum-frequency generation (SFG) spectroscopy.

SPECIFICATIONS

Model	SHBC
OUTPUT CHARACTERISTICS	
Output wavelength [1]	515 nm ± 5 nm
Conversion efficiency	> 30%
Spectral bandwidth [2]	< 10 cm^{-1}
Pulse duration [3]	2 – 4 ps
PUMP LASER REQUIREMENTS	
Pump source	PHAROS or CARBIDE with uncompressed output option
Pump pulse energy	40 µJ – 4 mJ
Maximum pump power	40 W
DIMENSIONS	
Housing (L × W × H)	426 × 351 × 119 mm
Recommended area for fixing (L × W × H)	450 × 400 × 150 mm

1) *Depends on pump laser model.*
2) *< 2 cm^{-1} model available; contact sales@lightcon.com.*
3) *SHBC can be adjusted to shorter pulse durations at the expense of narrow spectral bandwidth.*

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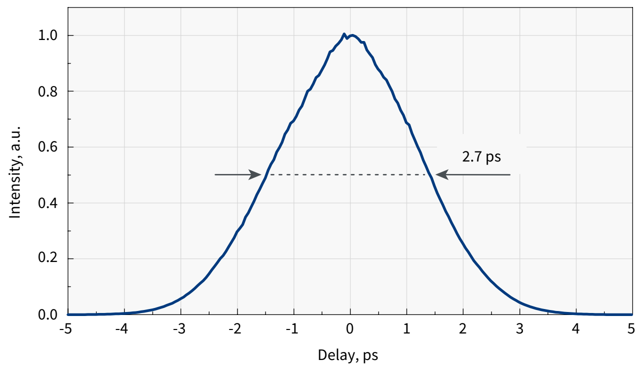
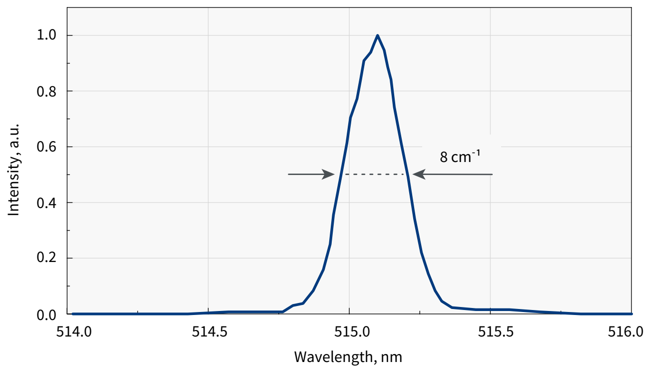
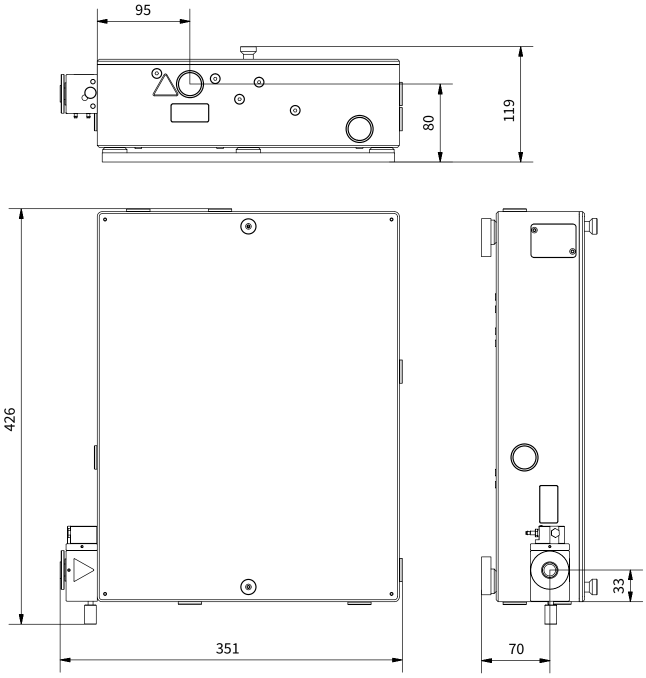


Typical pulse duration of SHBC output



Typical spectrum of SHBC output

DRAWINGS



ORPHEUS

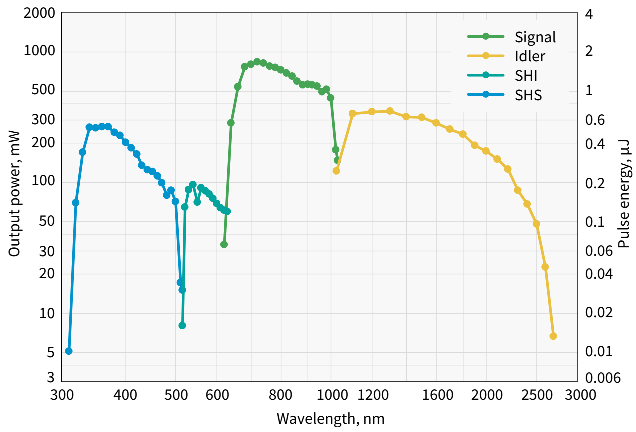
Collinear Optical Parametric Amplifier

FEATURES

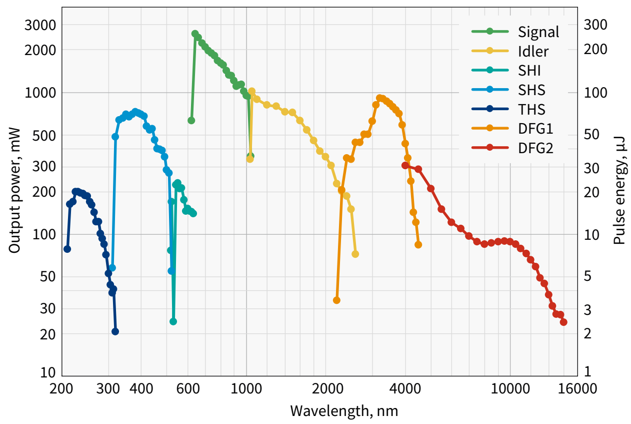
- 190 – 16000 nm tuning range
- Single-shot – 2 MHz repetition rate
- Up to 80 W pump power
- Up to 2 mJ pump pulse energy
- Completely automated

ORPHEUS is a collinear optical parametric amplifier (OPA) designed to provide the widest tuning range. Coupled with a PHAROS or CARBIDE laser, it emits femtosecond pulses tunable from ultraviolet to mid-IR at a repetition rate of up to 2 MHz. Accordingly, it is an invaluable tool for ultrafast spectroscopy, nonlinear microscopy, and microstructuring applications.

The base ORPHEUS model provides a tuning range from 630 to 2600 nm, which is extendable down to 210 nm with external harmonic generators. The ORPHEUS-HP model integrates all of the wavelength tuning options into a single thermally-stabilized housing. Output wavelength calibration and feedback is possible with an internal spectrometer. Its design offers completely hands-free wavelength tuning and automated wavelength separation, ensuring the same position and direction for the 190 – 2600 nm wavelength range. The mid-IR output is tunable from 2400 nm to 16 µm and has a separate output port. The ORPHEUS-HE model is designed for higher pump pulse energy.



Typical tuning curves of **ORPHEUS**.
Pump: 8 W, 16 µJ, 500 kHz



Typical tuning curves of **ORPHEUS-HE**.
Pump: 20 W, 2 mJ, 10 kHz

For custom tuning curves visit *http://toolbox.lightcon.com/tools/tuningcurves/*

SPECIFICATIONS

Model	ORPHEUS		ORPHEUS-HP		ORPHEUS-HE
OUTPUT FROM ORPHEUS					
Tuning range	630 –1030 nm (Signal) 1030 – 2600 nm (Idler)				
Integrated 2H (515 nm) generation efficiency	> 35% [1]		not specified		
Maximum pump power	8 W		80 W		
Pump pulse energy	8 – 20 µJ	20 – 400 µJ	8 – 20 µJ	20 – 400 µJ	400 – 2000 µJ [2]
Conversion efficiency at peak	> 6% (Signal and Idler combined)	> 12% (Signal and Idler combined)	> 4.5% (Signal) > 2% (Idler)	> 9% (Signal) > 4% (Idler)	
Pulse duration	120 – 250 fs				
Spectral bandwidth @ 700 – 960 nm	75 – 220 cm^{-1}				
Long-term power stability, 8 h [3]	< 2% @ 800 nm				
Pulse-to-pulse energy stability, 1 min [3]	< 2% @ 800 nm				
Features	Cost-effective		Completely automated		High energy & completely automated
OPTIONAL WAVELENGTH EXTENSIONS					
Pump pulse energy	8 – 20 µJ	20 – 400 µJ	8 – 20 µJ	20 – 400 µJ	400 – 2000 µJ [2]
SH package at peak 315 – 515 nm (SHS) 515 – 630 nm (SHI)	> 1.2%	> 3%	> 1.2%	> 2.4%	
210 – 315 nm (THS)	n/a		> 0.4% [4]	> 0.8% [4]	
FH package at peak 210 – 258 nm (FHS) 258 – 315 nm (FHI)	Contact sales@lightcon.com		n/a		
190 – 215 nm (DeepUV)	n/a			> 0.3% [5]	Contact sales@lightcon.com
2200 – 4200 nm (DFG1)	Contact sales@lightcon.com		> 1.5% @ 3000 nm	> 3% @ 3000 nm	
4000 – 16 000 nm (DFG2)			> 0.1% @ 10000 nm	> 0.2% @ 10000 nm	

[1] *At designated output port B.*
[2] *Pump energy of up to 5 mJ available; contact sales@lightcon.com for details.*
[3] *Expressed as NRMSD (normalized root mean squared deviation).*
[4] *Maximum output power of 400 mW.*
[5] *DeepUV conversion efficiency is specified for pump power of < 10 W. In case of higher pump power, conversion efficiency decreases. The maximum output power is limited to 40 mW @ 200 nm.*

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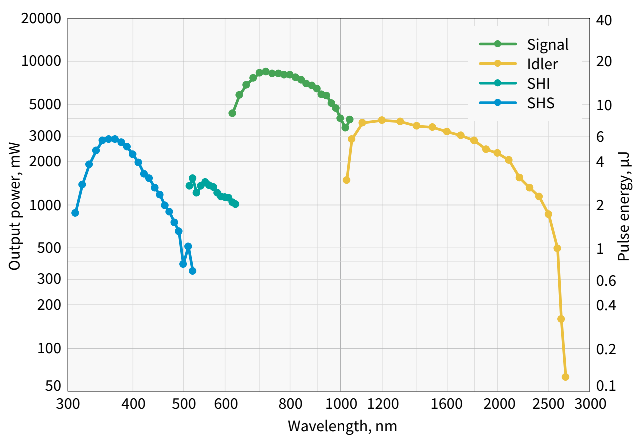
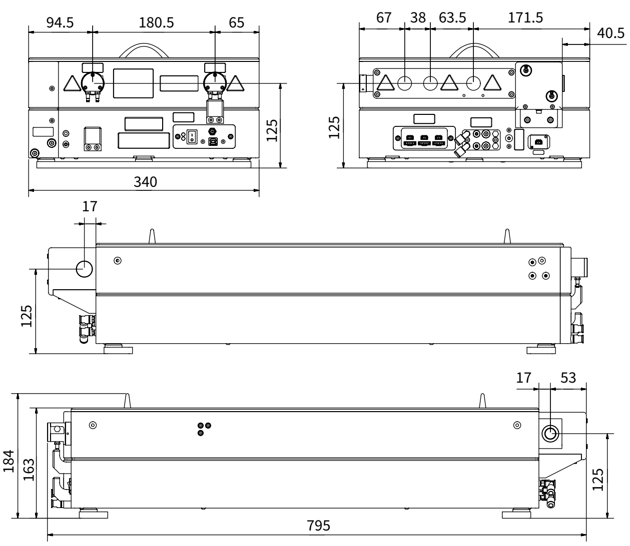


Typical tuning curves of **ORPHEUS-HP**.
Pump: 80 W, 160 µJ, 500 kHz



ORPHEUS-HP drawings

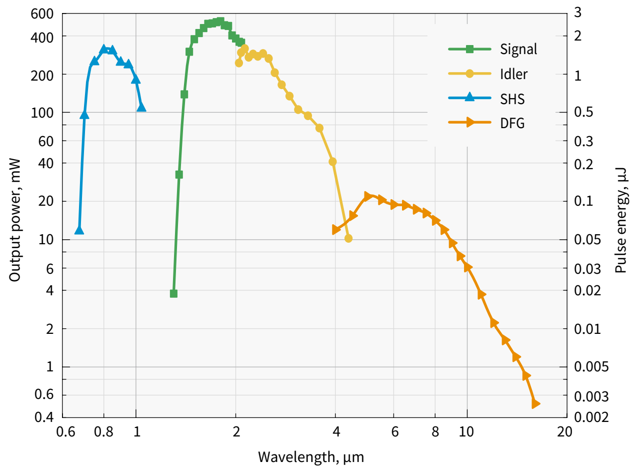
ORPHEUS | ONE

Mid-IR Collinear Optical Parametric Amplifier

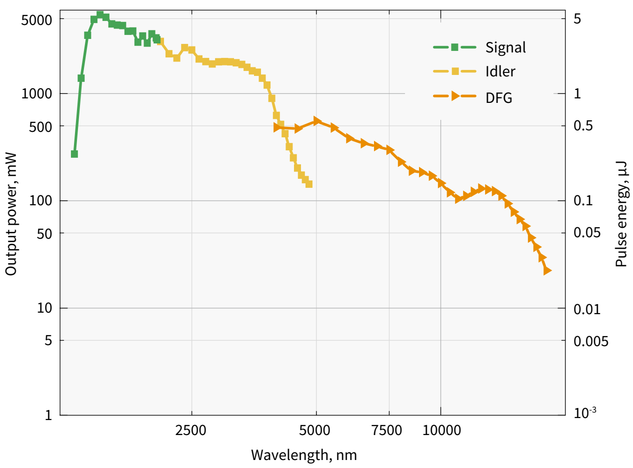
FEATURES

- High conversion efficiency in mid-IR
- 1350 – 16000 nm tuning range
- Single-shot – 2 MHz repetition rate
- Up to 80 W pump power
- Up to 2 mJ pump pulse energy

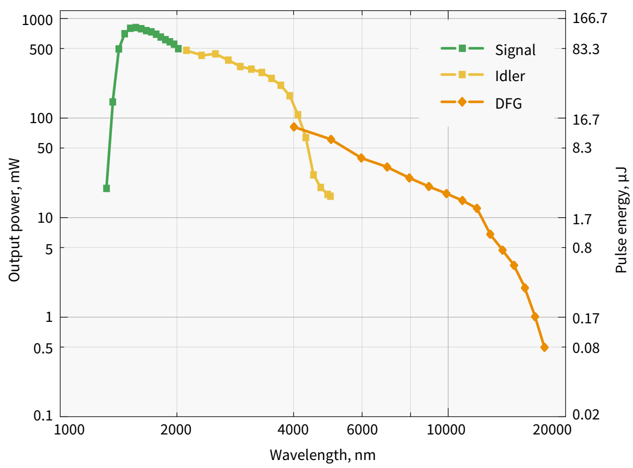
ORPHEUS-ONE is an optical parametric amplifier designed for the infrared spectral range. It has fewer wavelength extension options but provides higher conversion efficiency into mid-IR compared to ORPHEUS-HP. While ORPHEUS-ONE is simple and efficient, the output spectral bandwidth is limited by the pump pulses. For sum-frequency generation (SFG) spectroscopy and other applications requiring broad-bandwidth infrared pulses – consider ORPHEUS-MIR.



Typical tuning curves of **ORPHEUS-ONE**.
Pump: 6 W, 30 µJ, 200 kHz



Typical tuning curves of **ORPHEUS-ONE-HP**.
Pump: 40 W, 40 µJ, 1000 kHz



Typical tuning curves of **ORPHEUS-ONE-HE**.
Pump: 6 W, 1 mJ, 6 kHz

For custom tuning curves visit *http://toolbox.lightcon.com/tools/tuningcurves/*

SPECIFICATIONS

Model	ORPHEUS-ONE	ORPHEUS-ONE-HP	ORPHEUS-ONE-HE
OUTPUT FROM ORPHEUS-ONE (1350 – 4500 nm)			
Tuning range	1350 – 2060 nm (Signal) 2060 – 4500 nm (Idler)		
Maximum pump power	8 W	80 W	
Pump pulse energy	12 – 400 µJ	12 – 400 µJ	400 – 2000 µJ
Conversion efficiency at peak [1] (Signal and Idler combined)	> 14%, pump 30 – 2000 µJ > 10%, pump 12 – 30 µJ		
Spectral bandwidth	60 – 150 cm^{-1} @ 1450 – 2000 nm		60 – 150 cm^{-1} @ 1450 – 2000 nm
Long-term power stability, 8 h [2]	< 2% @ 1550 nm		
Pulse-to-pulse energy stability, 1 min [2]	< 2% @ 1550 nm		
Features	Cost-effective	High power	High energy

OPTIONAL WAVELENGTH EXTENSIONS

SH option	Tuning range	Contact sales@lightcon.com		
DFG option	Tuning range	4500 – 16000 nm (based on signal and idler calibration)		
	Conversion efficiency [1]	> 0.3% @ 10000 nm, when pump energy 30 – 2000 µJ > 0.2% @ 10000 nm, when pump energy 12 – 30 µJ		
	Spectral bandwidth	60 – 150 cm^{-1} @ 5000 – 8000 nm	60 – 120 cm^{-1} @ 5000 – 8000 nm	

[1] *Conversion efficiency specified as the percentage of pump power to ORPHEUS-ONE.*
[2] *Expressed as NRMSD (normalized root mean squared deviation).*

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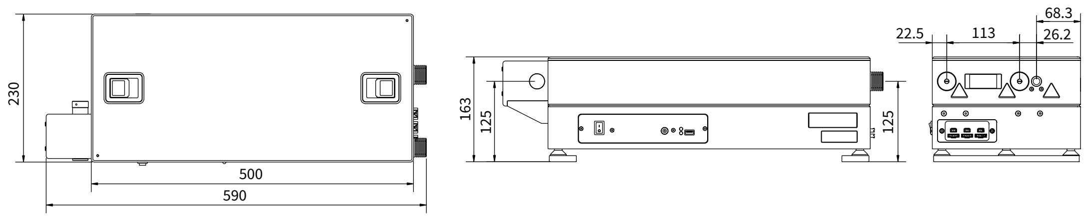
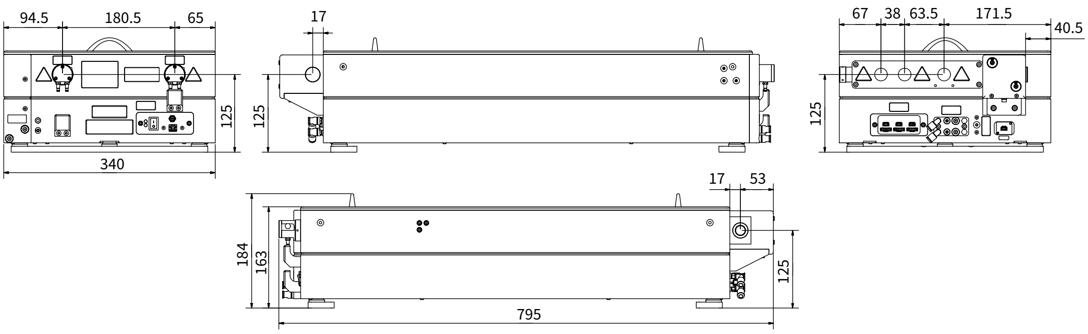
DRAWINGS



ORPHEUS-ONE drawings



ORPHEUS-ONE-HP / ORPHEUS-HP drawings

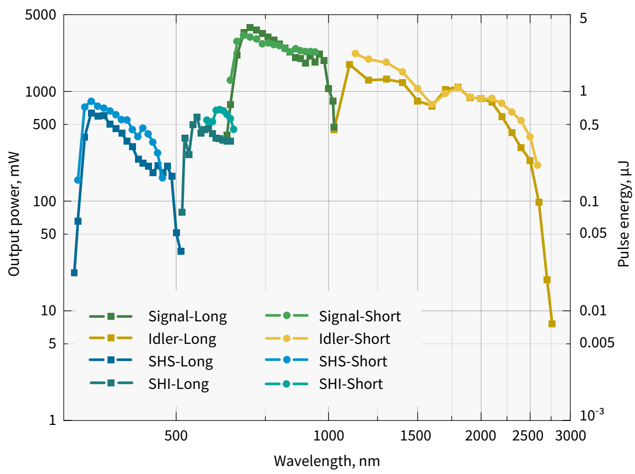
ORPHEUS | F

Broad-bandwidth Hybrid Optical Parametric Amplifier

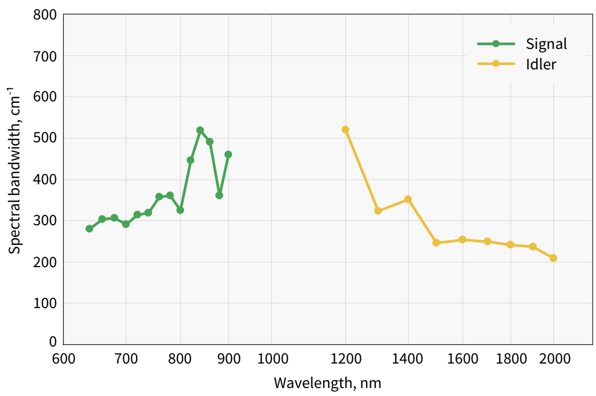
FEATURES

- Combination of the best collinear and non-collinear OPA features
- 650 – 900 nm & 1200 – 2500 nm tuning range
- Single-shot – 2 MHz repetition rate
- < 100 fs pulse duration
- Adjustable spectral bandwidth
- Optional long pulse mode for gap-free tunability

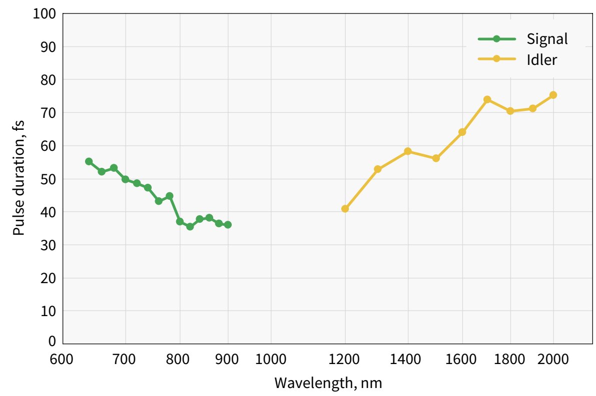
ORPHEUS-F is a hybrid optical parametric amplifier, combining the short pulse duration produced by a non-collinear OPA and the wide wavelength tuning range offered by a collinear OPA. The Signal pulses are tunable in a 650 – 900 nm wavelength range and can be compressed with a simple prism-based setup down to < 60 fs. The Idler pulses are tunable in a 1200 – 2500 nm tuning range and compressed down to 40 – 100 fs. Furthermore, an optional long-pulse mode is available for accessing the 900 – 1200 nm tuning range. Our non-collinear OPA ORPHEUS-N-2H produces broader bandwidths, is compressible down to <20 fs, but has a limited tuning range of 650 – 900 nm, while the standard ORPHEUS provides longer pulses, 200 – 300 fs. Thus, for many applications, ORPHEUS-F is the optimal choice.



Typical tuning curves of **ORPHEUS-F**.
Pump: 40 W, 40 μJ, 1000 kHz



Typical spectral bandwidth of ORPHEUS-F



Pulse duration after compression of ORPHEUS-F

For custom tuning curves visit
http://toolbox.lightcon.com/tools/tuningcurves/

SPECIFICATIONS

Model		ORPHEUS-F	
OUTPUT FROM ORPHEUS-F			
Mode of operation		Short pulse mode	Long pulse mode
Tuning range	**Signal**	650 – 900 nm	650 – 1010 nm
	Idler	1200 – 2500 nm	1050 – 2500 nm
Integrated 2H (515 nm) generation efficiency		> 35 % [1]	
Maximum pump power		80 W	
Pump pulse energy		10 – 500 µJ	
Conversion efficiency at peak		> 10% (Signal and Idler combined)	
Pulse duration before compression		< 290 fs	
Spectral bandwidth	650 – 900 nm	200 – 750 cm^{-1}	75 – 220 cm^{-1}
Pulse duration after compressor	800 – 900 nm	< 55 fs	n/a
	650 – 800 nm	< 70 fs	
	1200 – 2000 nm	< 100 fs	
	Typical: 650 – 900 nm	25 – 70 fs	
	Typical: 1200 – 2000 nm	40 – 100 fs	
Compressor transmission	650 – 900 nm	> 65%	
	1200 – 2000 nm	> 80%	
Long-term power stability, 8h [2]		< 2% @ 800 nm	
Pulse-to-pulse energy stability, 1 min [2]		< 2% @ 800 nm	
OPTIONAL WAVELENGTH EXTENSIONS			
Conversion efficiency at peak	325 – 450 nm (SHS)	> 1%	n/a
	325 – 505 nm (SHS)	n/a	> 1%
	525 – 650 nm (SHI)		> 0.5%
	600 – 650 nm (SHI)	> 0.5%	n/a
	210 – 252 nm (FHS)	n/a	> 0.1%
	263 – 325 nm (FHI)		> 0.1%
	2200 – 4200 nm (DFG1)	Contact sales@lightcon.com	
	4000 – 16000 nm (DFG2)		

[1] *At designated output port.*
[2] *Expressed as NRMSD (normalized root mean squared deviation).*

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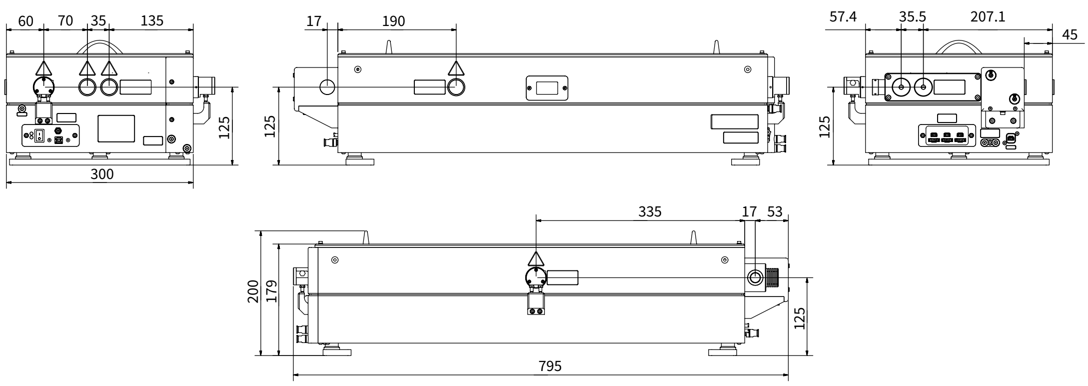
DRAWINGS



ORPHEUS-F drawings

ORPHEUS | MIR

NEW

Broad-bandwidth Mid-IR Optical Parametric Amplifier

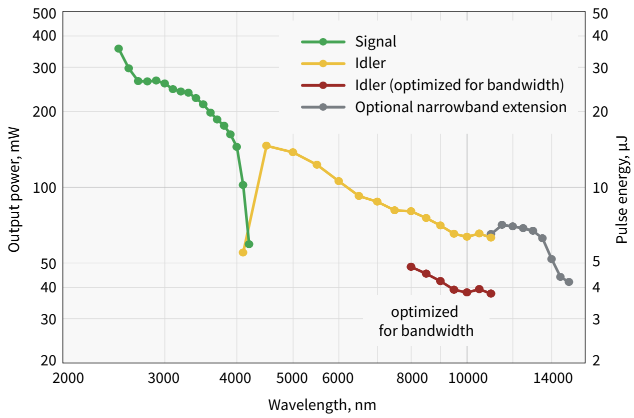
FEATURES

- Broad-bandwidth up to 500 cm^{-1}
- 2500 – 10 000 nm tuning range
- < 100 fs pulse duration
- Up to 80 W pump power
- Up to 2 mJ pump pulse energy
- Auxiliary short-pulse output at ≈ 2000 nm
- Optional narrow-bandwidth extension up to 15 000 nm
- Optional optimization for bandwidth
- Optional CEP stability

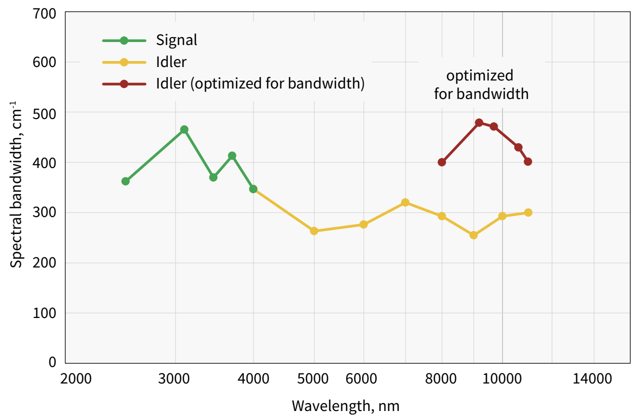
APPLICATIONS

- Broadband vibrational sum-frequency generation (SFG) spectroscopy
- Time- and angle-resolved photoemission spectroscopy (TR-ARPES)
- Two-dimensional infrared (2D IR) spectroscopy
- High-harmonic generation (HHG) in solids
- Other infrared spectroscopy and strong-field physics applications

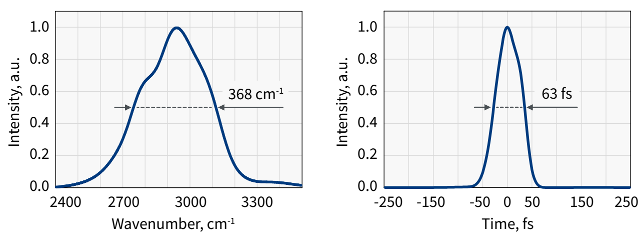
ORPHEUS-MIR is an OPA optimized for the efficient generation of broad-bandwidth mid-IR pulses. The system provides broadband pulses in the tuning range of 2.5 – 10 µm and reaches up to 15 µm with an optional narrow-bandwidth extension. Due to the novel system design, ORPHEUS-MIR provides < 100 fs pulses directly at the output. Signal and Idler outputs are available simultaneously. The system architecture is well-suited for high energy and high power PHAROS and CARBIDE lasers.



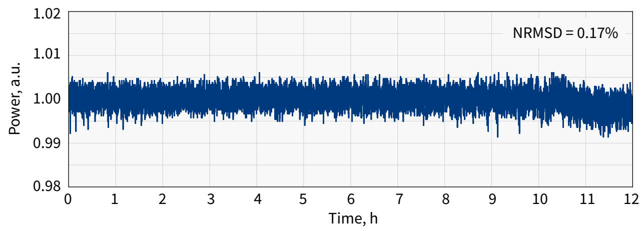
Typical tuning curves of **ORPHEUS-MIR**.
Pump: 20 W, 2 mJ, 10 kHz



Typical spectral bandwidth of **ORPHEUS-MIR**



Typical output spectrum (left) and pulse duration (right).
Measured at 3450 nm



Long-term power stability of **ORPHEUS-MIR**.
Measured over 12 h at 5000 nm

LIGHT CONVERSION

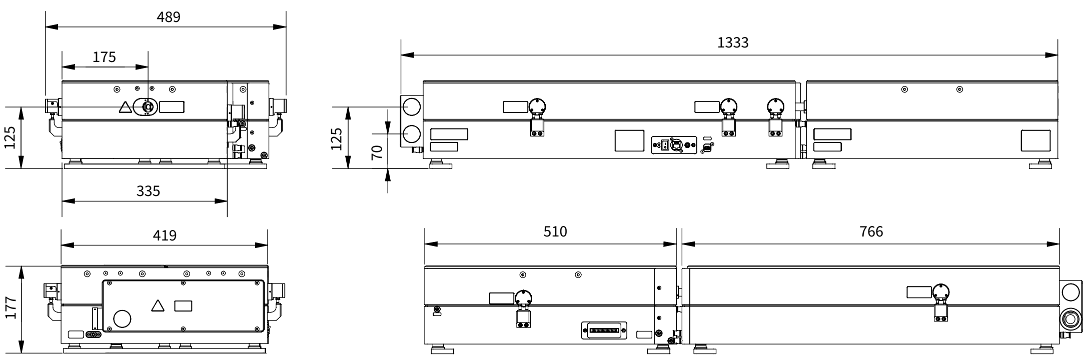
SPECIFICATIONS

Model	ORPHEUS-MIR	
MAIN OUTPUT (2500 – 10000 nm)		
Mode of operation	Standard	Optimized for bandwidth [1]
Tuning range	2500 – 4000 nm (Signal) 4000 – 10000 nm (Idler)	
Maximum pump power	80 W	
Pump pulse energy	200 µJ – 2 mJ	
Pulse duration	< 100 fs	
Conversion efficiency [2]	> 1.2% @ 3000 nm > 1.0% @ 3500 nm > 0.6% @ 5000 nm	
	> 0.3% @ 9000 nm	> 0.2% @ 9000 nm
Spectral bandwidth	> 300 cm^{-1} @ 2500 – 4000 nm > 200 cm^{-1} @ 4000 – 8000 nm	
	> 200 cm^{-1} @ 8000 – 10000 nm	> 350 cm^{-1} @ 8000 – 10000 nm
Long-term power stability, 8 h [3]	< 2% @ 5000 nm	
Pulse-to-pulse energy stability, 1 min [3]	< 2% @ 5000 nm	
AUXILIARY OUTPUT 1 (~2000 nm)		
Output wavelength	≈ 2000 nm (not tunable, optimized for best overall performance)	
Pulse duration	< 50 fs	
Conversion efficiency [2]	> 8%	
Spectral bandwidth	> 350 cm^{-1}	
AUXILIARY OUTPUT 2 (1350 – 2000 nm)		
Tuning range	1350 – 2000 nm	
Pulse duration	< 300 fs	
Conversion efficiency [2]	Contact sales@lightcon.com	
Spectral bandwidth	60 – 150 cm^{-1}	
OPTIONAL WAVELENGTH EXTENSION (10000 – 15000 nm)		
Tuning range	10000 – 15000 nm	
Pulse duration	< 300 fs	
Conversion efficiency [2]	> 0.2% @ 10000 – 15000 nm	
Spectral bandwidth	100 – 150 cm^{-1} @ 10000 – 15000 nm	

1) *Optional mode of operation. Optimized for maximum spectral bandwidth at expense of conversion efficiency.*
2) *Specified as a percentage of pump power.*
3) *Expressed as NRMSD (normalized root mean squared deviation).*

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

DRAWINGS



ORPHEUS-MIR drawings

ORPHEUS | N

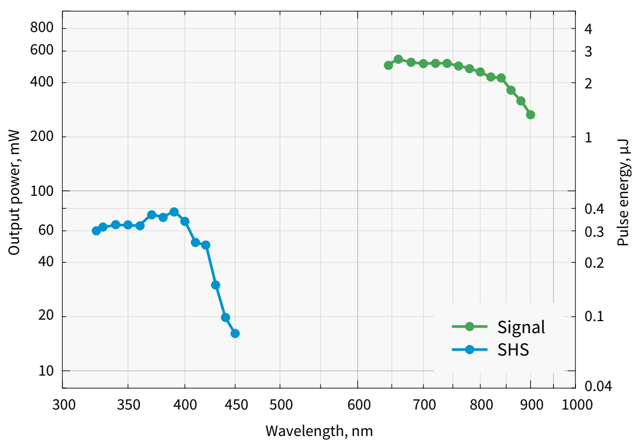
Non-Collinear Optical Parametric Amplifier

FEATURES

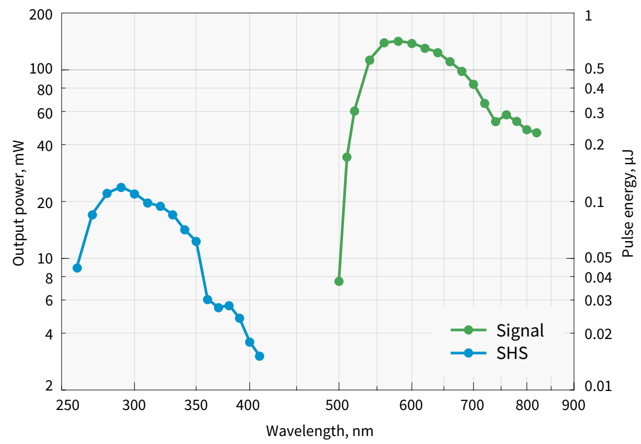
- < 30 fs pulse duration
- Single-shot – 1 MHz repetition rate
- Integrated prism compressor
- Adjustable spectral bandwidth and pulse duration
- Wavelength feedback with internal spectrometer

ORPHEUS-N is a non-collinear optical parametric amplifier (NOPA). Depending on the ORPHEUS-N model, it has a built-in second or third harmonic generator producing a 515 nm or 343 nm pump, respectively. ORPHEUS-N with a second harmonic pump (ORPHEUS-N-2H) delivers pulses of less than 30 fs in the 700 – 850 nm range. ORPHEUS-N with a third harmonic pump (ORPHEUS-N-3H) delivers pulses of less than 30 fs in the 530 – 670 nm range. ORPHEUS-N works at repetition rates of up to 1 MHz.

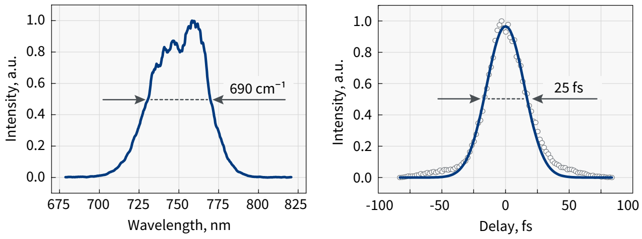
An optional second harmonic generator is available, extending the tuning range down to 260 – 450 nm. Featuring a built-in pulse compressor, ORPHEUS-N is an invaluable instrument for time-resolved spectroscopy. A single PHAROS or CARBIDE laser can pump more than one OPA device providing several pump and/or probe channels with independent wavelength tuning.



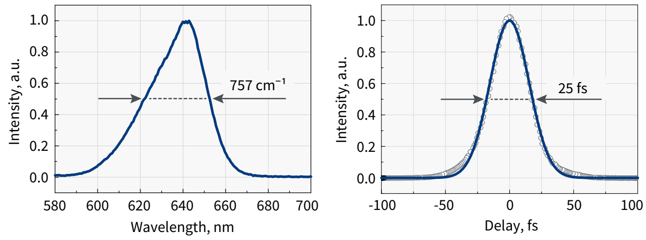
Typical tuning curves of **ORPHEUS-N-2H**
Pump: 6 W, 30 µJ, 200 kHz



Typical tuning curves of **ORPHEUS-N-3H**
Pump: 6 W, 30 µJ, 200 kHz



Typical output of **ORPHEUS-N-2H**



Typical output of **ORPHEUS-N-3H**

For custom tuning curves visit *http://toolbox.lightcon.com/tools/tuningcurves/*

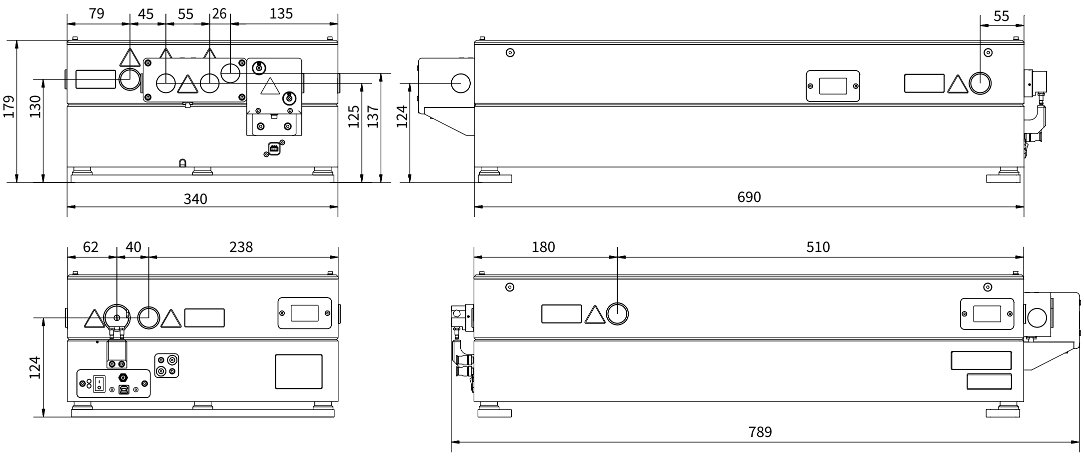
SPECIFICATIONS

Model	ORPHEUS-N-2H		ORPHEUS-N-3H		
OUTPUT FROM ORPHEUS-N					
Tuning range	650 – 900 nm (Signal)		520 – 900 nm (Signal)		
Integrated 2H / 3H generation efficiency	> 35% (515 nm)		> 25% (343 nm)		
Maximum pump power	8 W				
Pump pulse energy	10 – 200 µJ		12 – 200 µJ		
Conversion efficiency at peak	700 nm	800 nm	580 nm	700 nm	800 nm
	> 7%	> 5%	> 1.3%	> 0.7%	> 0.3%
Pulse duration after compressor	< 30 fs (700 – 850 nm)		< 30 fs (530 – 670 nm) < 80 fs (670 – 900 nm)		
Long-term power stability, 8 h [1]	< 2% @ 800 nm		< 2% @ 580 nm		
Pulse-to-pulse energy stability, 1 min [1]	< 2% @ 800 nm		< 2% @ 580 nm		
OPTIONAL WAVELENGTH EXTENSIONS					
Tuning range (SHS)	325 – 450 nm		260 – 450 nm		
Conversion efficiency at peak	> 10% of Signal				

[1] *Expressed as NRMSD (normalized root mean squared deviation).*

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

DRAWINGS



ORPHEUS-N drawings

ORPHEUS | TWINS

Dual Optical Parametric Amplifier

FEATURES

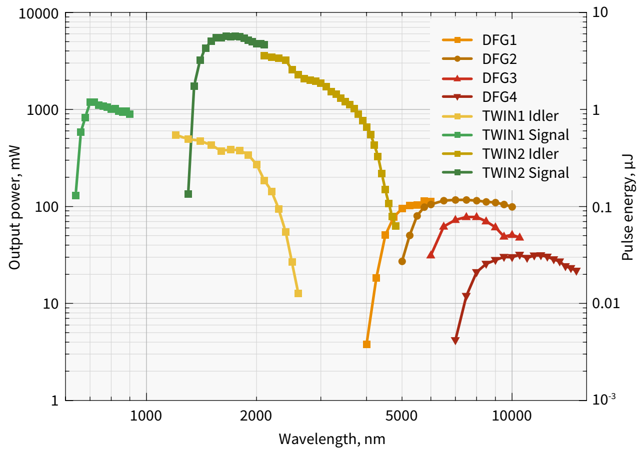
- Two OPA units in a single compact housing
- 210 – 16000 nm tuning range
- Single-shot – 2 MHz repetition rate
- Up to 60 W pump power
- Up to 0.5 mJ pump pulse energy
- CEP stable mid-IR output option

ORPHEUS-TWINS consists of two independently tunable optical parametric amplifiers (OPAs). The two channels can be separately configured to be a version of either ORPHEUS, ORPHEUS-ONE, ORPHEUS-F, or ORPHEUS-N-2H. Integrated into a single housing, both share the same white-light seed enabling the generation of broadband mid-IR radiation with a passively stable carrier-envelope phase (CEP).

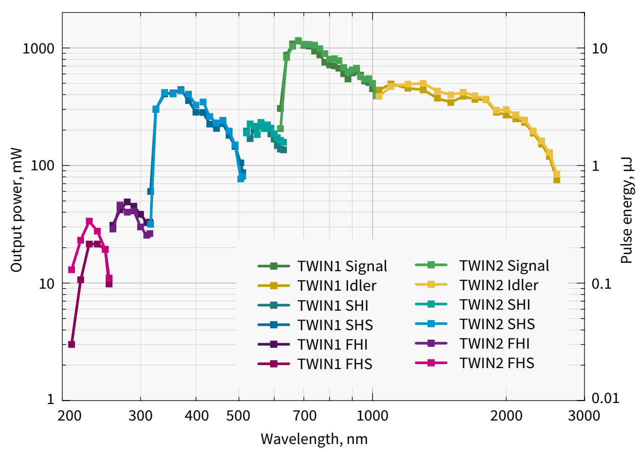
SPECIFICATIONS

Model	ORPHEUS-TWINS
OUTPUT FROM ORPHEUS-TWINS	
Tuning range	Choice between ORPHEUS, ORPHEUS-F, ORPHEUS-N-2H, and ORPHEUS-ONE configurations
Output pulse energy	Depends on the configuration – check the specifications of the chosen models
Spectral bandwidth	Depends on configuration, up to 100 – 750 cm^{-1}
Pulse duration	Depends on configuration, down to 40 fs
Supported repetition rates	Single-shot – 2 MHz
PUMP LASER REQUIREMENTS	
Required pump laser	PHAROS or CARBIDE
Wavelength	1030 nm
Pump pulse energy	16 – 500 µJ (up to 2 mJ on requests)
Pulse duration	180 – 300 fs
PHYSICAL DIMENSIONS	
Full dimension, including wavelength separators (W × L × H)	810 × 430 × 164 mm
Full dimensions of system with PHAROS laser and beam routing units (W × L × H)	910 × 850 × 215 mm

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT



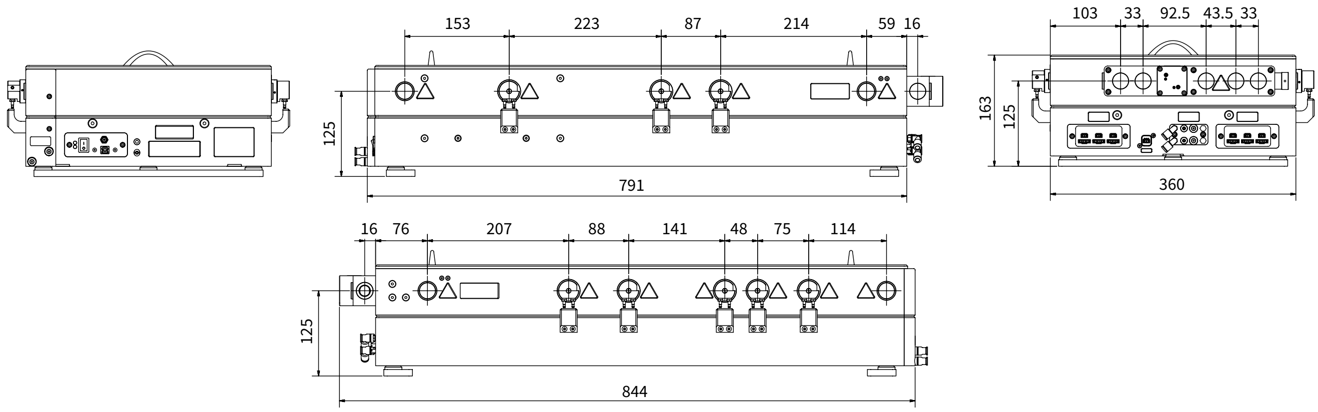
ORPHEUS-TWINS (ONE / F configuration)
tuning curves. Pump: 40 W, 40 µJ, 1 000 kHz



ORPHEUS-TWINS (ORPHEUS / ORPHEUS configuration)
tuning curves. Pump: 20 W, 20 µJ, 100 kHz

For custom tuning curves visit *http://toolbox.lightcon.com/tools/tuningcurves/*

DRAWINGS



ORPHEUS-TWINS drawings

ORPHEUS | PS

Narrow-Bandwidth Optical Parametric Amplifier

FEATURES

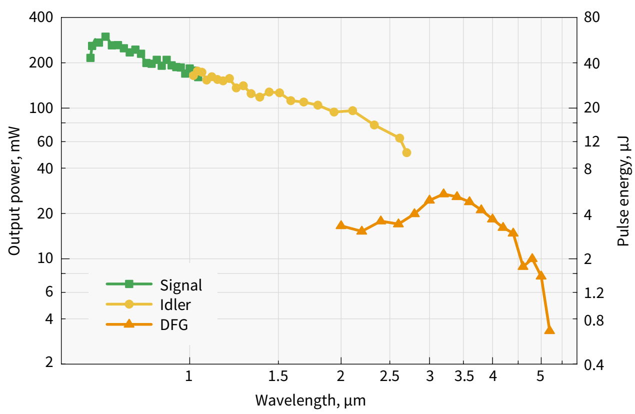
- 210 – 4800 nm tuning range
- 1 – 4 ps pulse duration
- Nearly bandwidth-limited output, < 15 cm^{-1} spectral bandwidth
- Up to 100 kHz repetition rate
- High stability by seeding with femtosecond white-light continuum

APPLICATIONS

- Femtosecond stimulated Raman spectroscopy (FSRS)
- Sum-frequency generation (SFG) spectroscopy

ORPHEUS-PS is a narrow-bandwidth optical parametric amplifier, designed for PHAROS and CARBIDE lasers. This device is pumped by the picosecond pulses produced in a second harmonic bandwidth compressor SHBC and is seeded by a white-light continuum generated by femtosecond pulses. This enables very high pulse-to-pulse stability compared to other methods of generating tunable picosecond pulses. The white-light generation module is integrated into the same housing as the amplification modules, enabling even better long-term stability and ease of use. The system features high conversion efficiency, bandwidth- and diffraction-limited output, and full computer control.

Part of the laser radiation can be split to simultaneously pump a femtosecond OPA, providing broad-bandwidth 630 nm – 16 µm tunable pulses, giving access to the complete set of beams necessary for versatile spectroscopy applications such as femtosecond stimulated Raman spectroscopy (FSRS) and sum-frequency generation (SFG) spectroscopy.

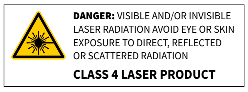


Orpheus-PS tuning curves.
Pump: 5 W, 1000 µJ, 5 kHz from PHAROS-SP.

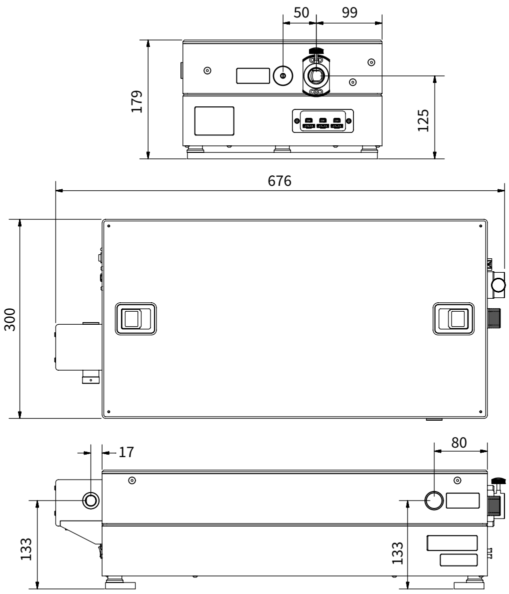
SPECIFICATIONS

Model		ORPHEUS-PS
OUTPUT FROM ORPHEUS-PS		
Tuning range		640 – 1000 nm (Signal) 1060 – 2600 nm (Idler)
Conversion efficiency at peak		> 8% (Signal and Idler combined)
Spectral bandwidth		< 20 cm^{-1} @ 700 – 2000 nm
Pulse duration		800 fs – 3 ps
Pulse-to-pulse energy stability [1)]		< 2% @ 700 – 960 nm & 1100 – 1500 nm
SHBC output		515 nm output port available, not simultaneous to OPA output Output pulse energy: > 15% of pump
Compressed pump output		1030 nm, < 300 fs, > 5 µJ
OPTIONAL WAVELENGTH EXTENSIONS		
SH option	Tuning range	320 – 500 nm (SHS) 530 – 640 nm (SHI)
	Conversion efficiency	> 3% at peak
FH option	Tuning range	210 – 250 nm (FHS) 265 – 320 nm (FHI)
	Conversion efficiency	> 0.3% at peak (for > 200 µJ pump energy)
DFG option	Tuning range	2400 – 4800 nm
	Conversion efficiency	> 0.25% at 3200 nm (for > 200 µJ pump energy)
PUMP LASER REQUIREMENTS		
Pump source		PHAROS or CARBIDE with uncompressed output option
Wavelength		1030 nm
Repetition rate		Single-shot – 100 kHz
Maximum pump power		20 W
Pump pulse energy		100 µJ – 3.2 mJ

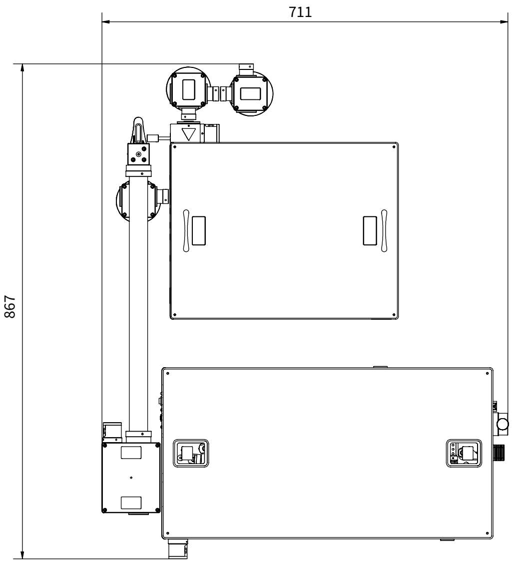
[1)] *Expressed as NRMSD (normalized root mean squared deviation).*



DRAWINGS



ORPHEUS-PS drawings



ORPHEUS-PS with SHBC drawing

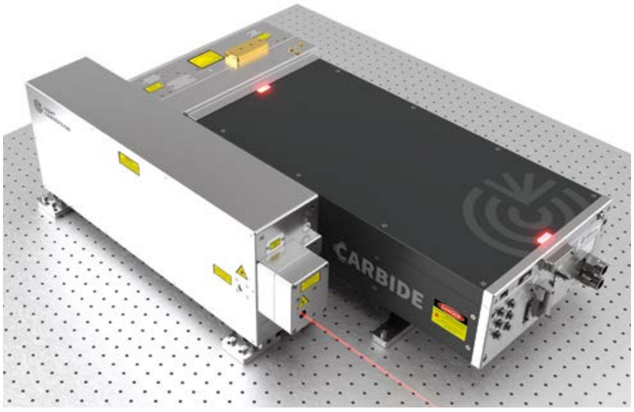
CRONUS | 3P

NEW

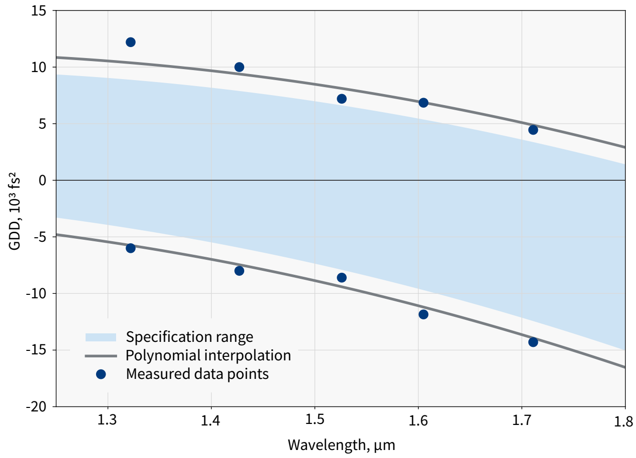
Laser Source for Advanced Nonlinear Microscopy

FEATURES

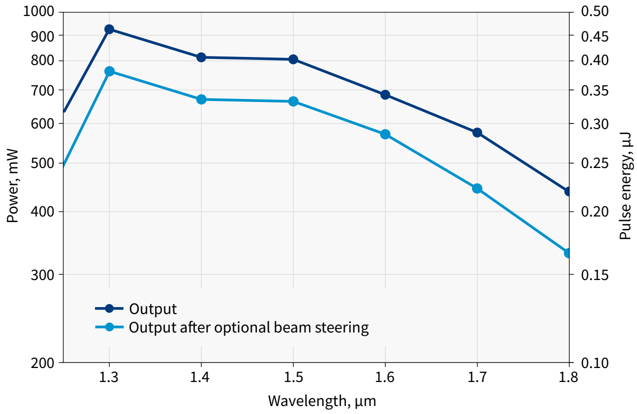
- High pulse energy, high repetition rate, and high average power
- 1250 – 1800 nm tuning range
- < 85 fs pulse duration
- Automated dispersion compensation
- Automated beam resizing and collimation
- High output stability
- Optional beam steering



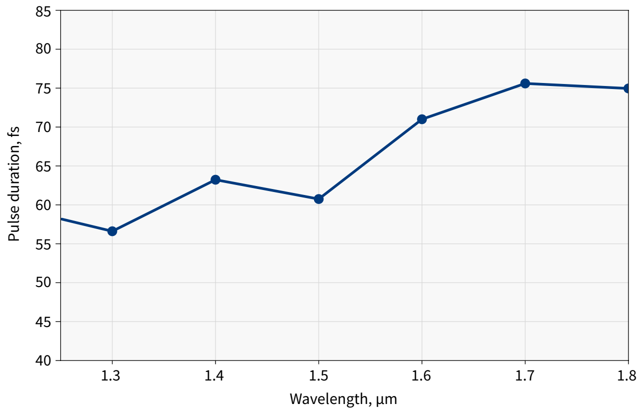
CRONUS-3P is an OPA-based laser source developed specifically for advanced nonlinear microscopy. It provides µJ-level sub-85 fs pulses at repetition rates of up to 2 MHz and tunable from 1.25 to 1.8 µm, thus covering the biological transparency windows at 1.3 µm and 1.7 µm for three-photon microscopy (3PEF). CRONUS-3P has integrated group delay dispersion (GDD) compensation, ensuring optimal pulse duration at the sample, and optional automated beam steering to guarantee laser pointing stability.



GDD tuning range



Output power and pulse energy vs wavelength.
Pump: 40 W, 2 MHz.



Typical pulse duration

SPECIFICATIONS

Model	CRONUS-3P	
Tuning range	1250 – 1800 nm	
Pulse duration	< 85 fs	
Repetition rate [1]	Single-shot to 2 MHz	
	1300 nm	**1700 nm**
Output power	> 1200 mW @ 1 MHz > 800 mW @ 2 MHz	> 750 mW @ 1 MHz > 500 mW @ 2 MHz
GDD compensation	-4000 – 9000 fs²	-12000 – 3500 fs²
Beam diameter [2]	1.5 – 2.5 mm	
Beam quality (M²)	< 1.4	
Beam ellipticity	> 0.8	
Beam divergence	< 1 mrad	
Long-term power stability, 8h [3]	< 1%	

OUTPUT WITHOUT COMPRESSOR

Output power	> 1500 mW @ 1 MHz > 1000 mW @ 2 MHz	> 1050 mW @ 1 MHz > 700 mW @ 2 MHz

OPTIONAL BEAM STEERING

Transmission	≥ 75%

[1] *Lower repetition rate and higher pulse energy options available.*
[2] *FWHM, measured at compressor output.*
[3] *Expressed as NRMSD (normalized root mean squared deviation).*

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
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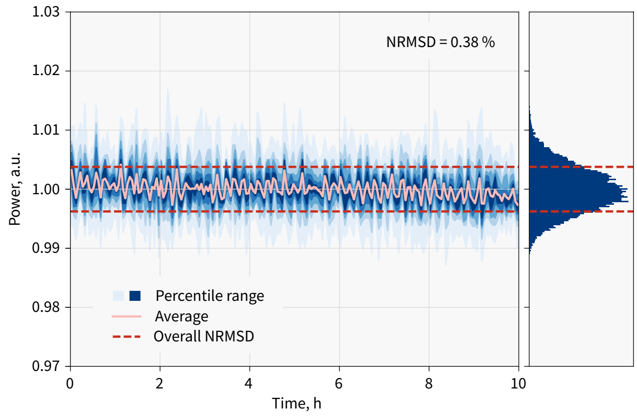
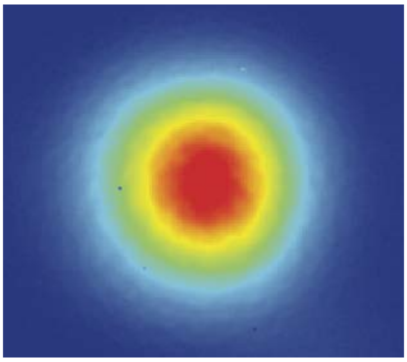
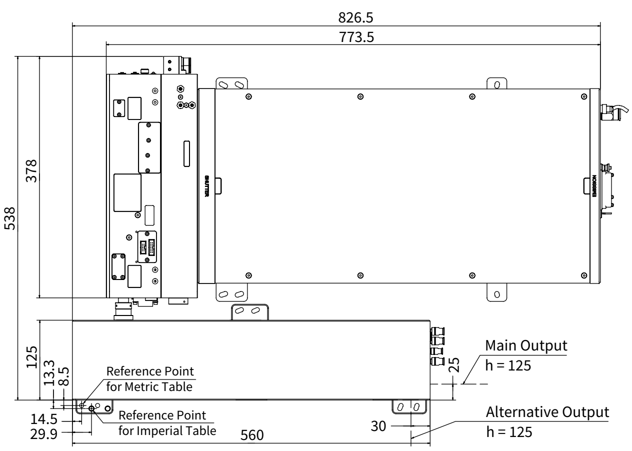


Long-term power stability,
measured at 1700 nm over 10 h

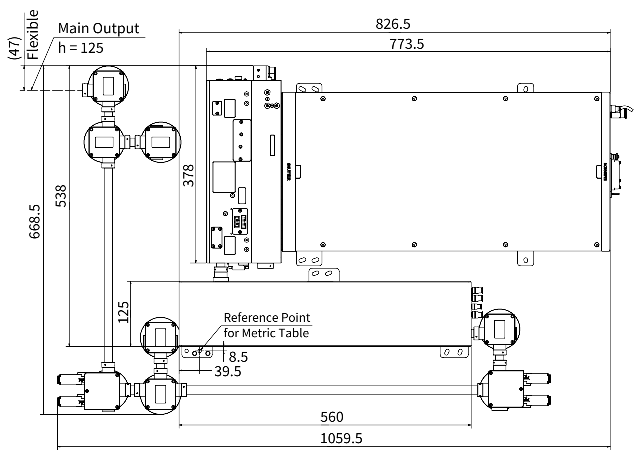


Beam profile at 1300 nm,
1.5 mm diameter (FWHM)

DRAWINGS



CRONUS-3P drawing



CRONUS-3P with optional beam steering drawing

TOPAS

Optical Parametric Amplifiers for Ti:Sapphire Lasers

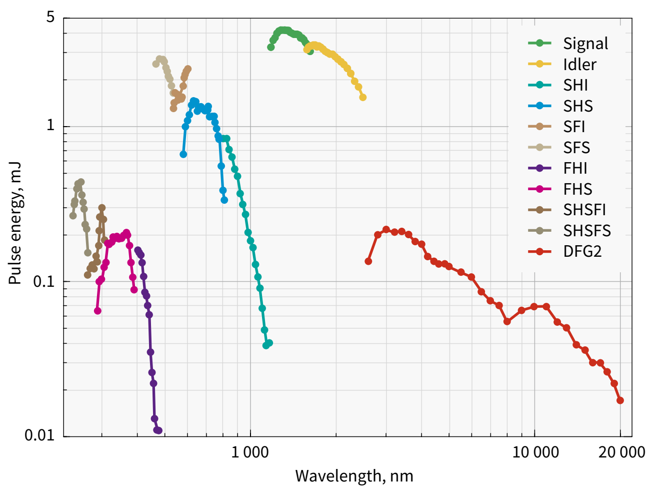
TOPAS is a series of femtosecond optical parametric amplifiers (OPAs) for Ti:Sapphire lasers which delivers continuous wavelength tunability from 189 nm to 20 µm, high conversion efficiency, high output stability, and full computer control. With more than 2000 units installed worldwide, TOPAS has become an OPA market leader for numerous scientific applications. TOPAS can be pumped by Ti:Sapphire lasers with pulse duration from 20 fs to 200 fs and pulse energy from 10 µJ to 60 mJ. Custom solutions beyond the given specifications are available; contact sales@lightcon.com for more details.

TOPAS | PRIME-HE

High Energy Optical Parametric Amplifier

FEATURES

- 189 nm – 20 µm tuning range
- Up to 60 mJ pump pulse energy
- Up to 50% conversion efficiency
- High output stability
- CEP stabilization of Idler
- Fresh pump channel for improved temporal and spatial properties of sum-frequency options



TOPAS-PRIME-HE tuning curves. Pump: 22 mJ, 45 fs, 805 nm

TOPAS-PRIME-HE is a high-energy femtosecond optical parametric amplifier based on TOPAS-PRIME with an additional high energy and low dispersion amplification stage which allows using pump pulse energy of up to 60 mJ while maintaining the shortest possible pulses at the output.

The standard TOPAS-PRIME-HE model accepts pump pulse energy of up to 8 mJ @ 35 fs (up to 20 mJ @ 100 fs), while TOPAS-PRIME-HE-PLUS accepts higher pump pulse energy, up to 18 mJ @ 35 fs (up to 47 mJ @ 100 fs). The pump pulse energy of 60 mJ is possible with longer pulses, ca. 150 fs. Both models come with wavelength extension options, covering the wavelength range from 189 nm to 20 µm for TOPAS-PRIME-HE and 240 nm to 20 µm for TOPAS-PRIME-HE-PLUS.

TOPAS | PRIME

Collinear Optical Parametric Amplifier

FEATURES

- 189 nm – 20 µm tuning range
- Up to 5 mJ pump pulse energy
- > 25% conversion efficiency
- High output stability
- CEP stabilization of Idler
- Fresh pump channel for improved temporal and spatial properties of sum-frequency options

TOPAS-PRIME is a collinear femtosecond optical parametric amplifier designed for Ti:sapphire lasers.

The standard TOPAS-PRIME model accepts pump pulse energy of up to 3.5 mJ @ 35 fs (up to 4 mJ @ 100 fs), while TOPAS-PRIME-PLUS accepts higher pump pulse energy, up to 5 mJ @ 35 – 100 fs. Both models come with wavelength extension options, covering a wavelength range from 189 nm to 20 µm.

TOPAS | SHBC-400

Narrow-Bandwidth Optical Parametric Amplifier

FEATURES

- Femtosecond pulse conversion to < 20 cm^{-1} spectral bandwidth
- 240 nm – 10 µm tuning range
- Up to 4 mJ pump pulse energy
- High output stability

TOPAS-SHBC-400 combines a second harmonic bandwidth compressor (SHBC) and an optical parametric amplifier (OPA) for the generation of tunable pulses with a spectral bandwidth of 3 – 20 cm^{-1} when pumped by femtosecond pulses with a spectral bandwidth of 150 – 500 cm^{-1}. The device is designed to be pumped by a fundamental harmonic of a femtosecond Ti:Sapphire laser and covers a wavelength range from 480 to 2400 nm.

Optional frequency mixers extend the tuning range down to 240 nm and up to 10 µm.

TOPAS | TWINS

Dual Optical Parametric Amplifier

FEATURES

- Two independently tunable outputs
- 240 nm – 20 µm tuning range, in each channel
- > 25% conversion efficiency
- High output stability

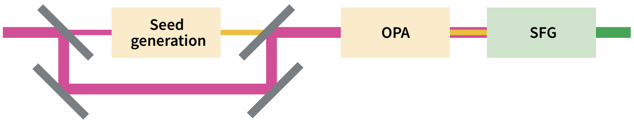
TOPAS-TWINS consists of two independently tunable optical parametric amplifiers (OPAs) integrated into a single housing. Both OPAs share the same white light source to provide excellent stability of both outputs, and CEP stabilized mid-IR pulses in a tuning range of 4.5 – 15 µm.

Both OPAs come with wavelength extension options, covering the wavelength range from 240 nm to 20 µm. Output specifications for each OPA are the same as those of TOPAS-PRIME. The maximum pump pulse energy depends on the pulse duration; see the specifications for more details.

FRESH PUMP OPTION

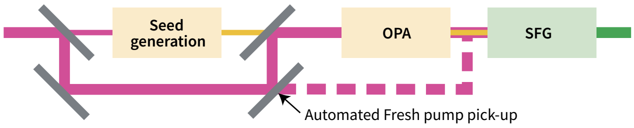
TOPAS-PRIME option for sum-frequency generation (SFG) in 475 – 580 nm range.

DEPLETED PUMP OPTION

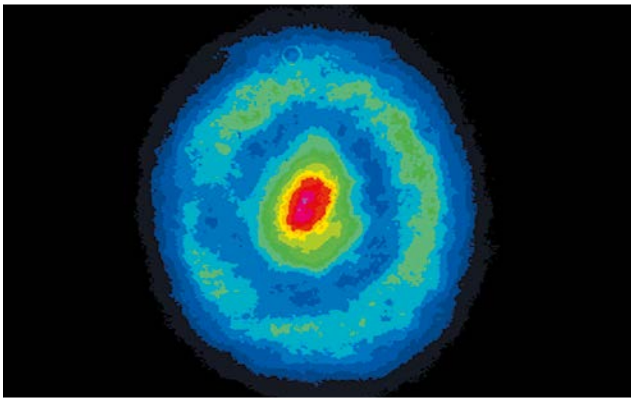


Optical scheme with depleted pump for SFG

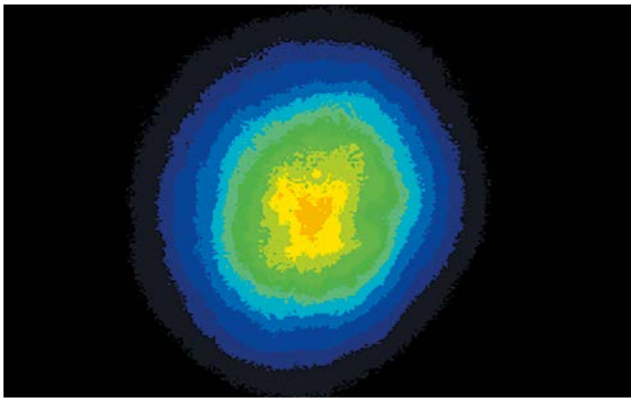
FRESH PUMP OPTION



Optical scheme with fresh pump for SFG



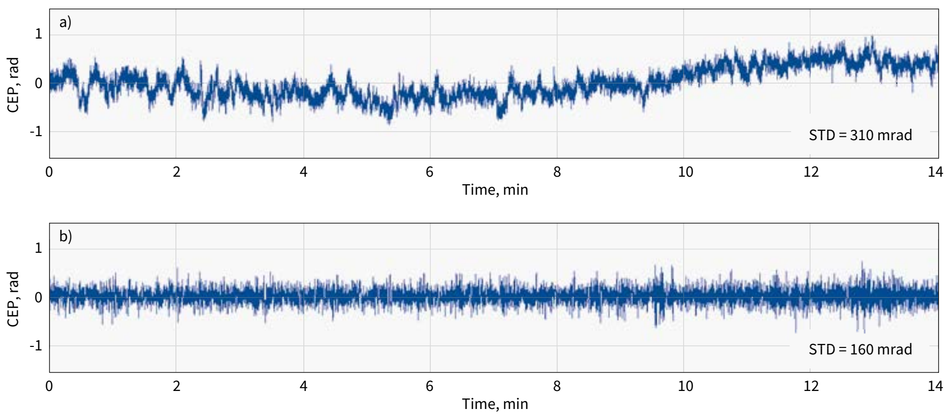
SFG output beam profile using depleted pump



SFG output beam profile using fresh pump

CEP STABILIZATION OF IDLER

TOPAS Idler (1600 – 2600 nm) is passively CEP locked due to a three-wave interaction. However, a slow CEP drift may persist because of changes in pump beam pointing or environmental conditions. Such a drift can be compensated by employing an f-2f interferometer and a feedback loop controlling the temporal delay between seed and pump in the power amplification stage of TOPAS-PRIME and TOPAS-PRIME-HE.



CEP stability of Idler over 14 min.
(a) without compensation of drift, (b) with compensation of drift with a slow loop

NIRUVIS

Frequency Mixer

FEATURES

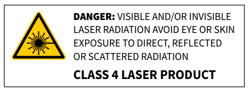
- Automated wavelength tuning and separation
- Single output port for all wavelengths in 240 – 2600 nm range, constant position and direction
- Consistent output beam polarization
- High output pulse contrast
- High conversion efficiency of Idler related interactions

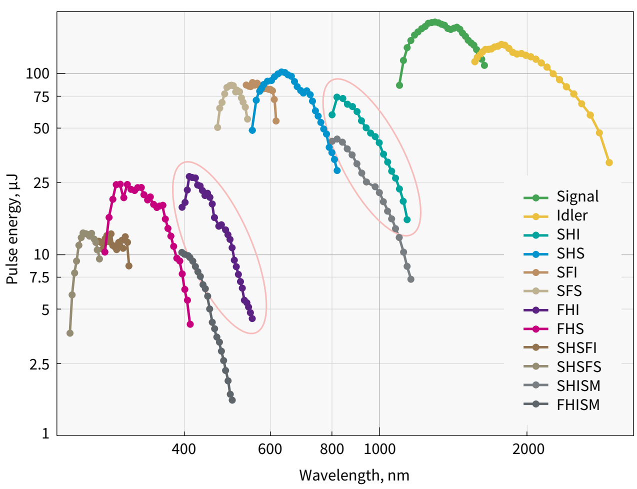
NIRUVIS is a frequency mixer for TOPAS-PRIME and TOPAS-PRIME-HE. It consists of three automated nonlinear crystal stages in a monolithic housing. The output is generated by a second and fourth harmonic generation as well as sum-frequency generation. In contrast to free-standing frequency mixers, NIRUVIS offers high conversion efficiency, simple operation, compact design, and low environmental sensitivity. Furthermore, wavelength separation after each nonlinear interaction ensures high output pulse contrast.

SPECIFICATIONS

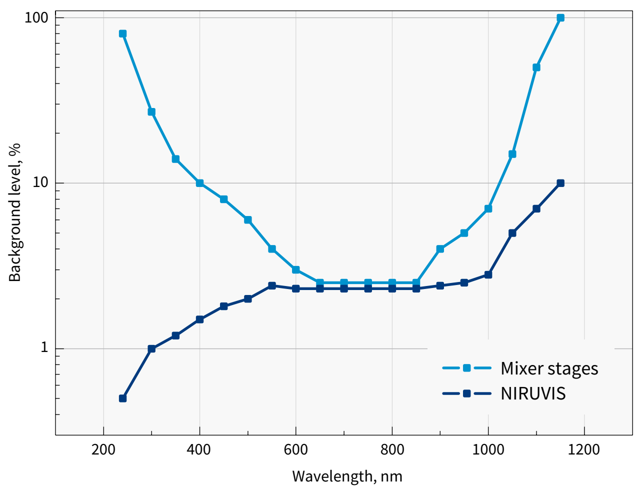
Model	Automated NIRUVIS	Standard NIRUVIS	NIRUVIS-DUV
Maximum tuning range	240 – 1160 nm		189 – 1160 nm
Type of tuning	Fully automated	Manual, using wavelength separators	
Number of output ports	Single output port for all wavelengths	4 output ports (wavelength-dependent)	
Fresh pump option [1]	Included	Optional	Included

[1] *See page 46 for details.*





Tuning curves of TOPAS-PRIME with fresh pump option and NIRUVIS (SHISM and FHISM achieved with separate mixing stages). Pump: 1 mJ, 100 fs, 800 nm.



Background level comparison between NIRUVIS and separate mixing stages

OPCPA

Optical Parametric Chirped-Pulse Amplification Systems

FEATURES OVERVIEW

- Customizable light source for applications requiring the shortest pulses and extreme peak and average powers
- 800 nm – 3 μm wavelengths, extendable to mid-IR
- Up to 5 TW peak power
- Down to 6.5 fs pulse duration
- 100 Hz – 200 kHz repetition rate
- < 250 mrad CEP stability

Optical parametric chirped-pulse amplification (OPCPA) is the only currently available laser technology simultaneously providing high peak and average power, as well as few-cycle pulse duration required by the most demanding scientific applications.

LIGHT CONVERSION's answer to these demands is a portfolio of cutting-edge OPCPA products based on years of experience in developing and manufacturing optical parametric amplifiers and femtosecond lasers.

OPCPA system delivering 5.5 TW peak power (6.6 fs, 36 mJ) pulses.
Built for ELI-ALPS in collaboration with Ekspla.

ORPHEUS | OPCPA

Compact Few-cycle CEP-stable OPCPA Systems

Pumped by PHAROS or CARBIDE Lasers

Benefiting from the industrial-grade stability and reliability of the PHAROS and CARBIDE lasers, ORPHEUS-OPCPA delivers few-cycle, CEP-stable pulses in a package as compact as our standard parametric amplifiers. The different ORPHEUS-OPCPA models all use the same base architecture to produce CEP-stable, few-cycle pulses in one of the four wavelength ranges. ORPHEUS-OPCPA is available in versions with pulse compressors for direct use in applications or in versions intended as seed sources, delivering background-free pulses with near-single-cycle bandwidths, excellent spectral phase coherence, and CEP stability.

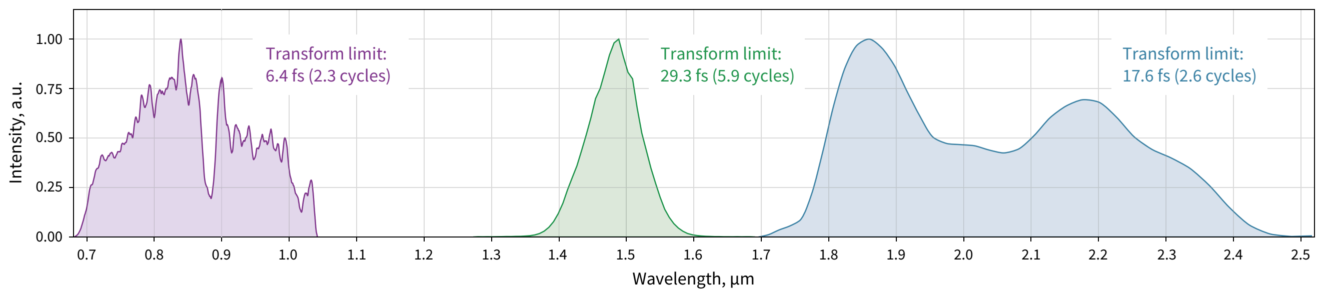
ORPHEUS-OPCPA-HR

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

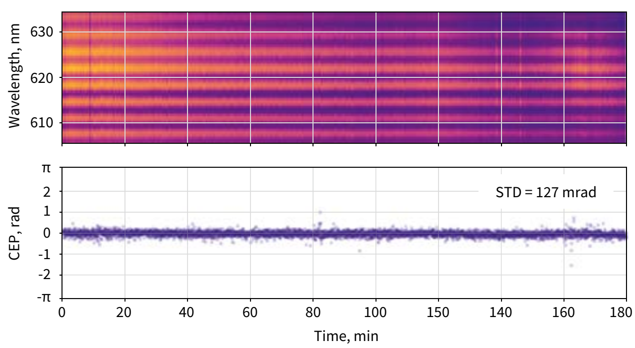
CONFIGURATIONS

Wavelength	800 nm	1.6 µm	2 µm	3 µm
Pulse duration (compressed)	< 10 fs	< 40 fs	< 25 fs	< 45 fs
Transform-limited pulse duration (uncompressed, for seeding larger amplifiers)	< 6 fs	< 30 fs	< 15 fs	< 35 fs

	Repetition rate	Pulse energy / Output power			
ORPHEUS-OPCPA	10 kHz	120 µJ / 1.2 W	240 µJ / 2.4 W	180 µJ / 1.8 W	120 µJ / 1.2 W
ORPHEUS-OPCPA-HE		0.55 mJ / 5.5 W	1.1 mJ / 11 W	0.8 mJ / 8 W	0.5 mJ / 5 W
ORPHEUS-OPCPA-HR	100 kHz	25 µJ / 2.5 W	55 µJ / 5.5 W	40 µJ / 4 W	30 µJ / 3 W
ORPHEUS-OPCPA-HP		100 µJ / 10 W	220 µJ / 22 W	150 µJ / 15 W	120 µJ / 12 W

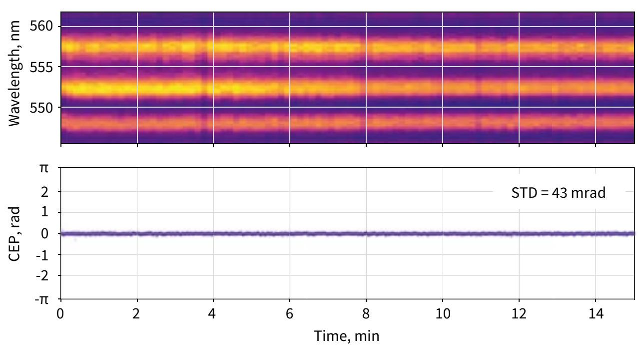


Example spectra of three models of ORPHEUS-OPCPA



CEP stability of ORPHEUS-OPCPA (800 nm, 100 kHz)

All CEP values calculated from unaveraged, single-shot measurements!



CEP stability of ORPHEUS-OPCPA (3 µm, 1 kHz)

All CEP values calculated from unaveraged, single-shot measurements!

OPCPA | HR

High Repetition Rate OPCPA Systems

Pumped by InnoSlab or Thin-Disk Lasers, Optionally Seeded by ORPHEUS-OPCPA

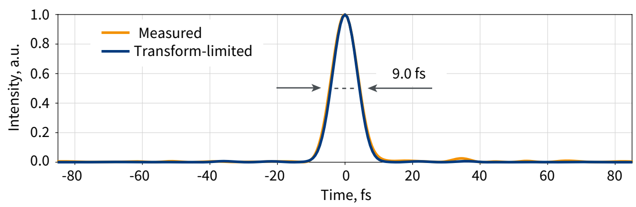
InnoSlab and thin-disk lasers based on Yb:YAG are the state-of-the-art high average power lasers of today. These lasers lend themselves extremely well to pumping OPCPA systems, and LIGHT CONVERSION is happy to offer OPCPA solutions designed to work with these lasers. Available either bundled with state-of-the-art multi-100 W lasers or as standalone modules designed to work with your laser.

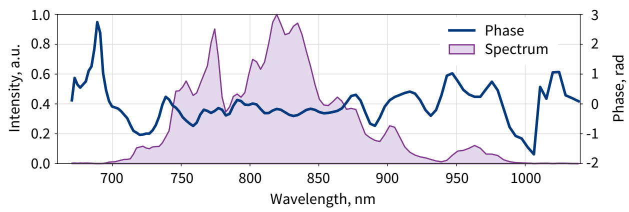
- Wavelength(s), pulse duration, and energy are customizable – contact sales@lightcon.com for more details.
- A single pump laser can be combined with more than one OPCPA option in either switchable or simultaneous operation

CONFIGURATIONS

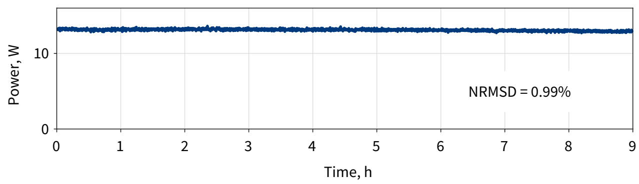
Wavelength	800 nm	1.6 µm	2 µm	3 µm
Pulse duration	< 9 fs	< 35 fs	< 25 fs	< 35 fs

	Repetition rate	Pulse energy / Output power			
HR-20	20 kHz	0.8 mJ / 16 W	1.6 mJ / 32 W	1.3 mJ / 26 W	0.8 mJ / 16 W
HR-200	200 kHz	110 µJ / 22 W	270 µJ / 54 W	200 µJ / 40 W	130 µJ / 26 W





ORPHEUS-HR output pulse and spectrum



Output power stability over 9 h of OPCPA-HR (800 nm, 100 kHz)

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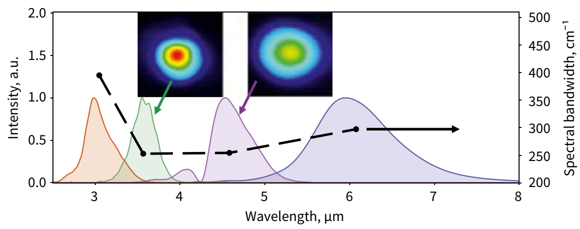
CLASS 4 LASER PRODUCT

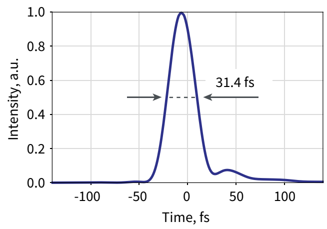
Mid-IR Wavelength Extensions

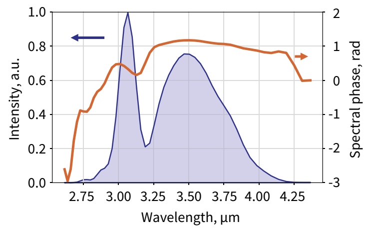
For ORPHEUS-OPCPA and OPCPA-HR

2 µm models of ORPHEUS-OPCPA and OPCPA-HR can be equipped with a DFG module for efficient generation of tunable broad-bandwidth mid-IR pulses; contact sales@lightcon.com for more details.



Example spectra using ORPHEUS-OPCPA DFG module





Output pulse and spectrum at 3.4 µm using ORPHEUS-OPCPA DFG module

OPCPA | HE

High Energy OPCPA Systems

Pumped by Picosecond Nd:YAG Lasers, Seeded by ORPHEUS-OPCPA

Applications like high-energy attosecond pulse generation, generation of high harmonics from solid targets, and laser electron acceleration all benefit from few-cycle pulse durations and excellent pulse contrast while requiring multi-millijoule pulse energy. Our most powerful high energy OPCPA systems are scalable to multi-TW peak powers at kHz repetition rates while maintaining few-cycle pulse durations. They will fit the most demanding requirements while providing stability and reliability unprecedented for systems of this scale.

SYLOS launched in ELI-ALPS facility

CONFIGURATIONS

Wavelength	800 nm	1.6 µm	2 µm
Pulse duration	< 9 fs	< 50 fs	< 30 fs

	Repetition rate	Pulse energy / Output power		
HE-100 [1]	100 Hz	50 mJ	100 mJ	50 mJ
HE-1000 [2]	1 kHz	50 mJ / 50 W	100 mJ / 100 W	50 mJ / 50 W

[1] *Cost- and size-effective highly-stable multi-TW source.*
[2] *Cutting-edge combination of peak and average power.*

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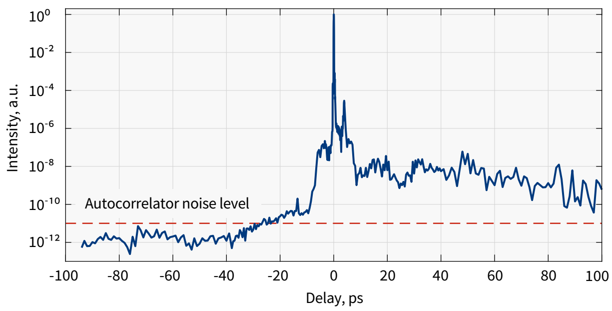
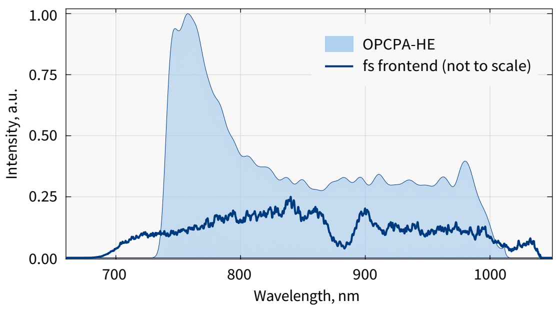
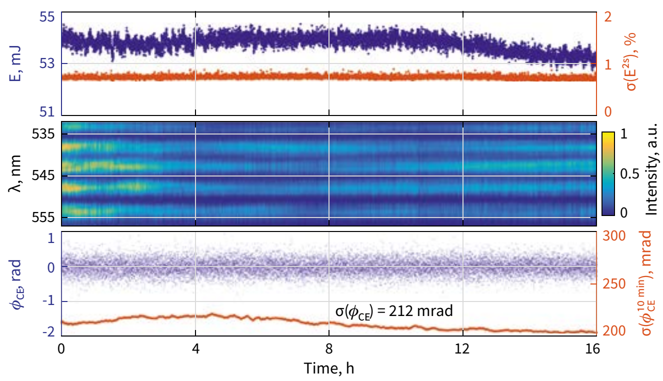


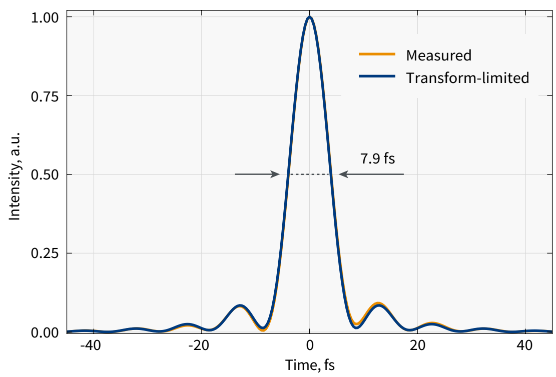
High-dynamic-range third order autocorrelation measurement of an OPCPA-HE system



OPCPA-HE output spectrum



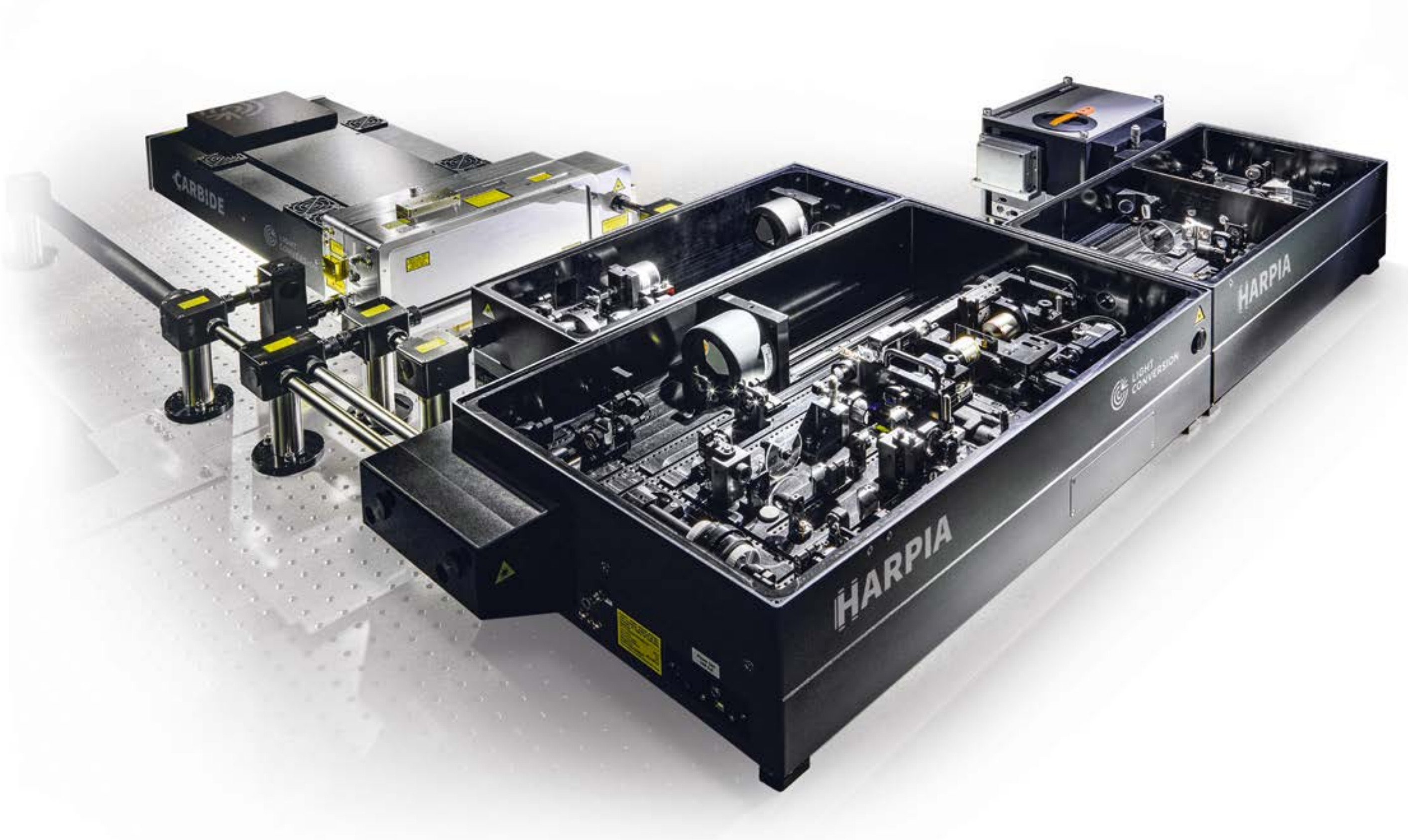
OPCPA-HE pulse energy, f-2f interferogram and CEP stability measured over 16 h



Temporal profile of OPCPA-HE output pulses measured with a self-referenced spectral interferometry device

HARPIA

Comprehensive Spectroscopy System



The HARPIA comprehensive spectroscopy system performs a variety of sophisticated time-resolved spectroscopic measurements in a compact footprint. It offers an intuitive user experience and easy day-to-day maintenance meeting the needs of today's scientific applications. Extension modules and customization options tailor the HARPIA system to specific measurement needs.

The system is built around the HARPIA-TA transient absorption spectrometer and can be expanded using time-correlated single-photon counting and fluorescence upconversion (HARPIA-TF), third beam delivery (HARPIA-TB), and microscopy (HARPIA-MM) modules. HARPIA is designed for easy switching between measurement modes and comes with dedicated data acquisition and analysis software. Each module is contained in a monolithic aluminum body ensuring excellent optical stability and minimal optical path lengths. For a single-supplier solution, the HARPIA spectroscopy system can be combined with a PHAROS or a CARBIDE laser together with ORPHEUS series OPAs. HARPIA also supports Ti:sapphire lasers with TOPAS series OPAs.

APPLICATIONS

- Femtosecond transient absorption and reflection in bulk and microscopy modes
- Femtosecond multi-pulse transient absorption and reflection
- Femtosecond fluorescence upconversion
- Femtosecond stimulated Raman scattering (FSRS)
- Picosecond-to-microsecond fluorescence TCSPC
- Intensity-dependent transient absorption and reflection
- Flash photolysis
- Z-scan

HARPIA | TA

Ultrafast Transient Absorption Spectrometer

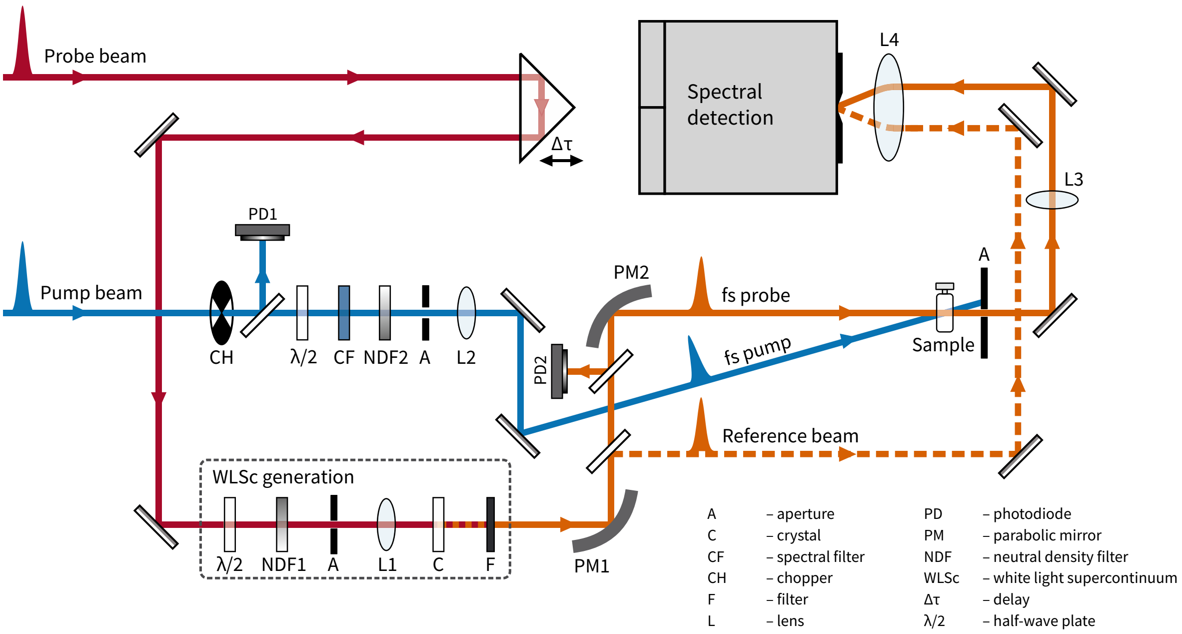
FEATURES

- Market-leading sensitivity
- 330 nm – 24 µm spectral range
- Probe delay ranges from 2 ns to 8 ns
- Pump pulse energies down to nJ
- Cryostat and peristaltic pump support

The HARPIA-TA ultrafast transient absorption spectrometer features market-leading characteristics such as 0.05 mOD (10^{-4} ΔT/T) sensitivity and the ability to work at high repetition rates up to 1 MHz, when used with a PHAROS or CARBIDE laser and an ORPHEUS series OPA. A high repetition rate allows measuring transient absorption dynamics with excitation pulse energies down to several nanojoules.

Several probe light configurations and detection options are available: from a photodiode for single-wavelength detection to white-light supercontinuum probing, combined with spectrally-resolved broadband detection. HARPIA-TA features integrated data acquisition and measurement control electronics providing automated pump and probe beam position tracking and alignment, motorized Berek polarization compensator, motorized supercontinuum generator, automated harmonic switching, an automated sample stage, as well as switching between transient absorption and transient reflection measurements. Delay range from 2 ns to 8 ns is available. The broadband probe covers the 330 – 1600 nm wavelength range and monochromatic probe enables the spectral range extension up to 24 µm.

HARPIA-TA is compatible with cryostats and peristaltic pumps, and the capabilities of the spectrometer can be further extended using expansion modules.



HARPIA-TA optical layout for pump-probe experiments

SPECIFICATIONS

Probe excitation wavelength	1030 nm	515 nm	800 nm
Probe wavelength range	470 – 1600 nm	350 – 750 nm	330 – 1400 nm
Spectral range of multichannel detectors	200 – 1100 nm, 700 – 1800 nm, or 1.2 – 2.6 µm		
Spectral range of single-channel detectors	180 nm – 24 µm		
Delay range	2 ns, 4 ns, or 8 ns		
Delay resolution	2.1 fs, 4.2 fs, or 8.3 fs		
Laser repetition rate	1 – 1000 kHz		
Time resolution	< 1.4x of pump or probe pulse duration, whichever is longer		
Maximum data acquisition rate	4000 spectra/s		
Physical dimensions (L×W×H)	730 × 420 × 160 mm [1)]		
Sample chamber area (L×W)	205 × 215 mm		

[1)] *Without external spectrograph.*

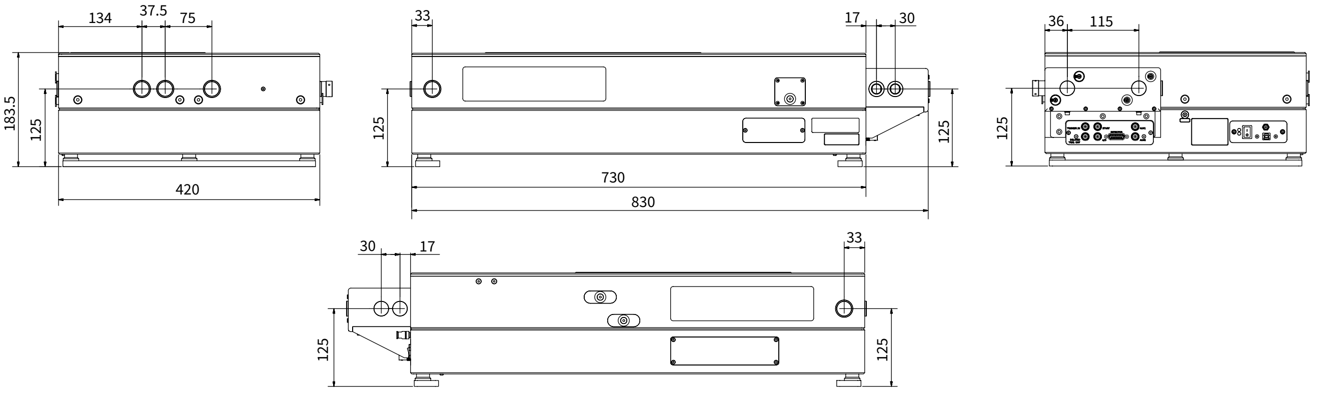
DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

CRYOSTAT MOUNTING OPTION

HARPIA-TA supports cryostats that can be mounted externally or internally. For more details contact sales@lightcon.com.

Internal cryostat mounting option

DRAWINGS



HARPIA-TA drawings

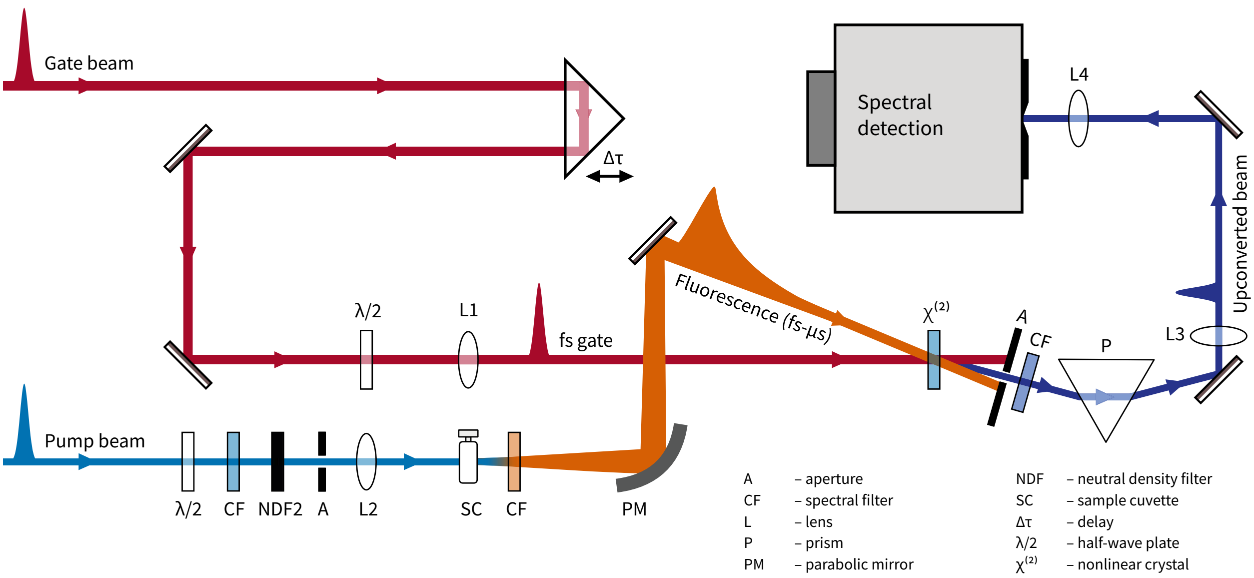
HARPIA | TF

Femtosecond Fluorescence Upconversion and TCSPC Module

FEATURES

- Picosecond-to-microsecond fluorescence TCSPC
- Automated switching between fluorescence upconversion and TCSPC measurements
- Automated spectral scanning and calibration
- Optional operation as a stand-alone unit

The HARPIA-TF is a time-resolved fluorescence measurement module that combines fluorescence upconversion and TCSPC techniques. In fluorescence upconversion, the signal from the sample is mixed in a nonlinear crystal with a gating femtosecond pulse to achieve high temporal resolution, which is limited by the duration of the gate pulse and is in the range of 250 fs. For fluorescence decay times exceeding 150 ps, the instrument can be used in time-correlated single-photon counting (TCSPC) mode to measure kinetic traces in the 200 ps – 2 µs range. The combination of the two methods enables the measurement of spectrally-resolved fluorescence decay in the femtosecond to microsecond range. Using a high repetition rate PHAROS or CARBIDE laser, the fluorescence dynamics can be measured while exciting the samples with pulse energies down to several nanojoules.



HARPIA optical layout for fluorescence upconversion measurements

SPECIFICATIONS

TCSPC MODE

TCSPC module	Becker&Hickl SPC 130
Photomultiplier	Becker&Hickl PMC-150 or HPM-100
Emission wavelength range	300 – 820 nm
Intrinsic time resolution	< 200 ps
Time resolution with monochromator	< 1.2 ns [1)]
SNR	< 100 : 1, assuming 5 s averaging per trace [2)]

UPCONVERSION MODE

Wavelength range	300 – 1600 nm [3)]
Wavelength resolution	Limited by the bandwidth of the gating pulse, typically around 100 cm^{-1}
Delay range	2 ns, 4 ns, or 8 ns
Delay resolution	2.1 fs, 4.2 fs, or 8.3 fs
Time resolution	< 1.4× of the pump or probe pulse duration, whichever is longer; 420 fs with a PHAROS laser [4)]
SNR	65 : 1, assuming 0.5 s averaging per point [5)]

1) *Estimated as the FWHM of the upconverted white-light supercontinuum generated in the sample.*
2) *Estimated by fitting a kinetic trace measured in Rhodamine 6G solution at 580 nm with multiple exponents, subtracting the fit from the data and taking the ratio between the standard deviation of the residuals and the 0.5× maximum signal value; 250 kHz repetition rate. Not applicable to all samples and configurations.*
3) *Depending on the gating source, full range covered with different nonlinear crystals.*
4) *Estimated as the FWHM of the upconverted white-light supercontinuum generated in the sample or the derivative of the rise of the upconversion signal.*
5) *Estimated as the standard deviation of a set of 100 points at 50 ps intervals measured in Rhodamine 6G dye at an upconverted wavelength of 360 nm using a PHAROS laser running at 150 kHz repetition rate. Not applicable to all samples and configurations.*

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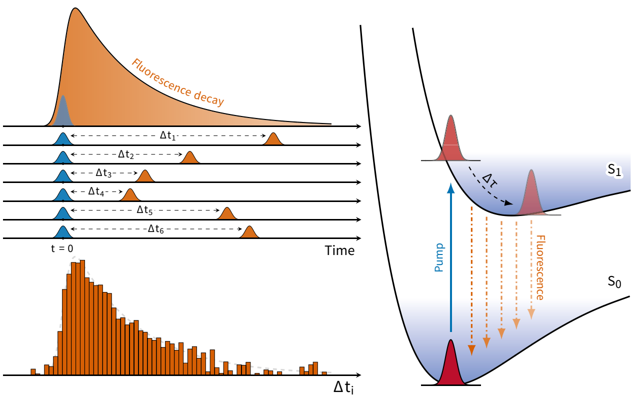
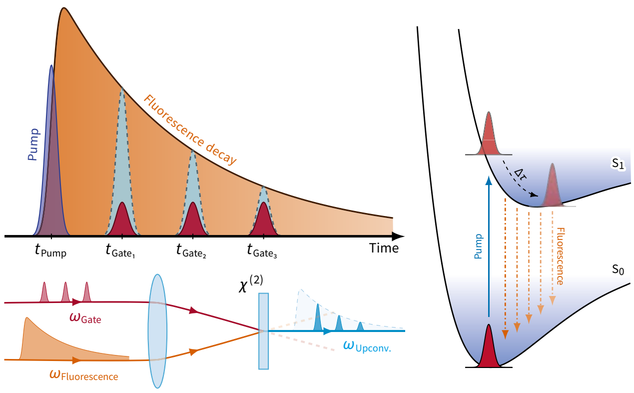


Principle of time-correlated single-photon counting (TCSPC)



Principle of time-resolved fluorescence upconversion

HARPIA | TB

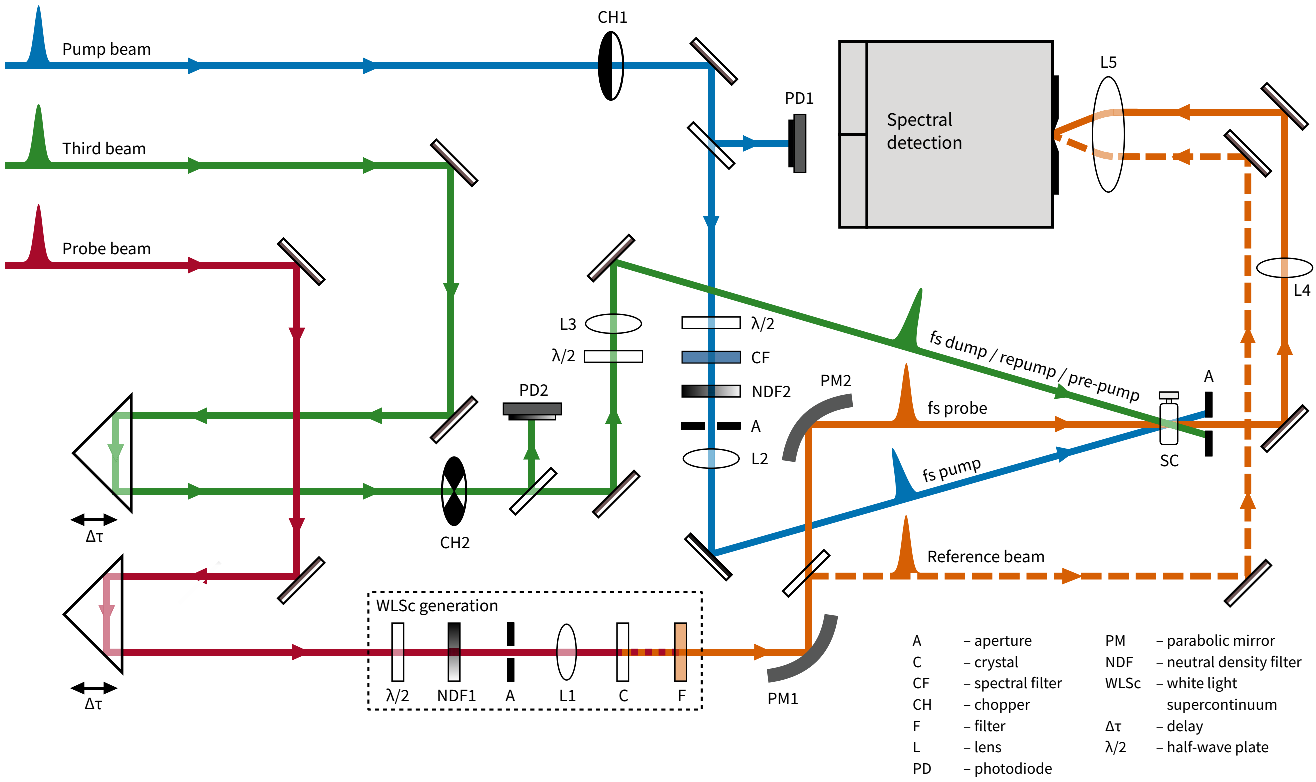
Third Beam Delivery Module

FEATURES

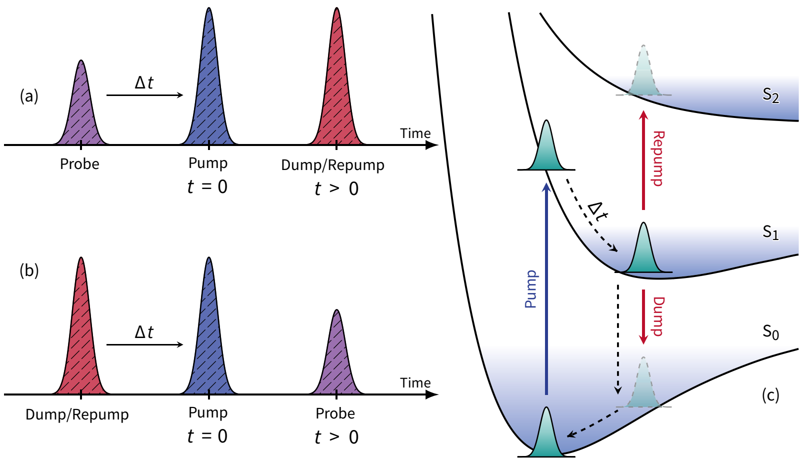
- Delivery of an additional femtosecond or picosecond beam
- Polarization, intensity, and delay control
- Femtosecond stimulated Raman scattering (FSRS) support
- Z-scan support

The HARPIA-TB is a third beam delivery module for the HARPIA-TA unit that adds an additional dimension to time-resolved absorption measurements. It allows multi-pulse time-resolved spectroscopic techniques, in which the ongoing pump-probe photodynamics are perturbed by a delayed third pulse.

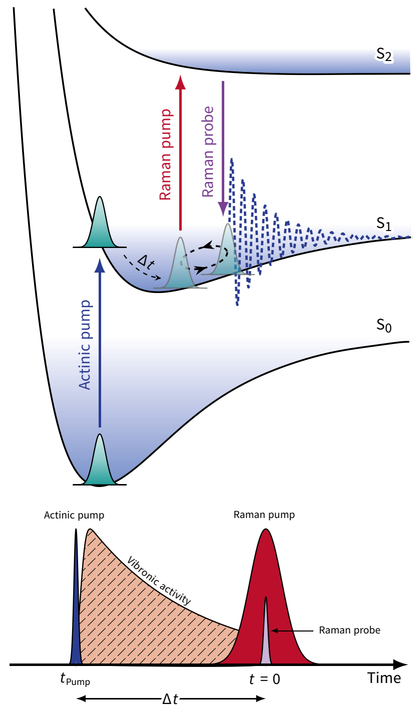
In conjunction with a narrow-bandwidth picosecond pulse source, HARPIA-TB can be used to perform femtosecond stimulated Raman scattering (FSRS) measurements. Furthermore, HARPIA-TB supports Z-scan measurements.



HARPIA optical layout for multi-pulse experiments

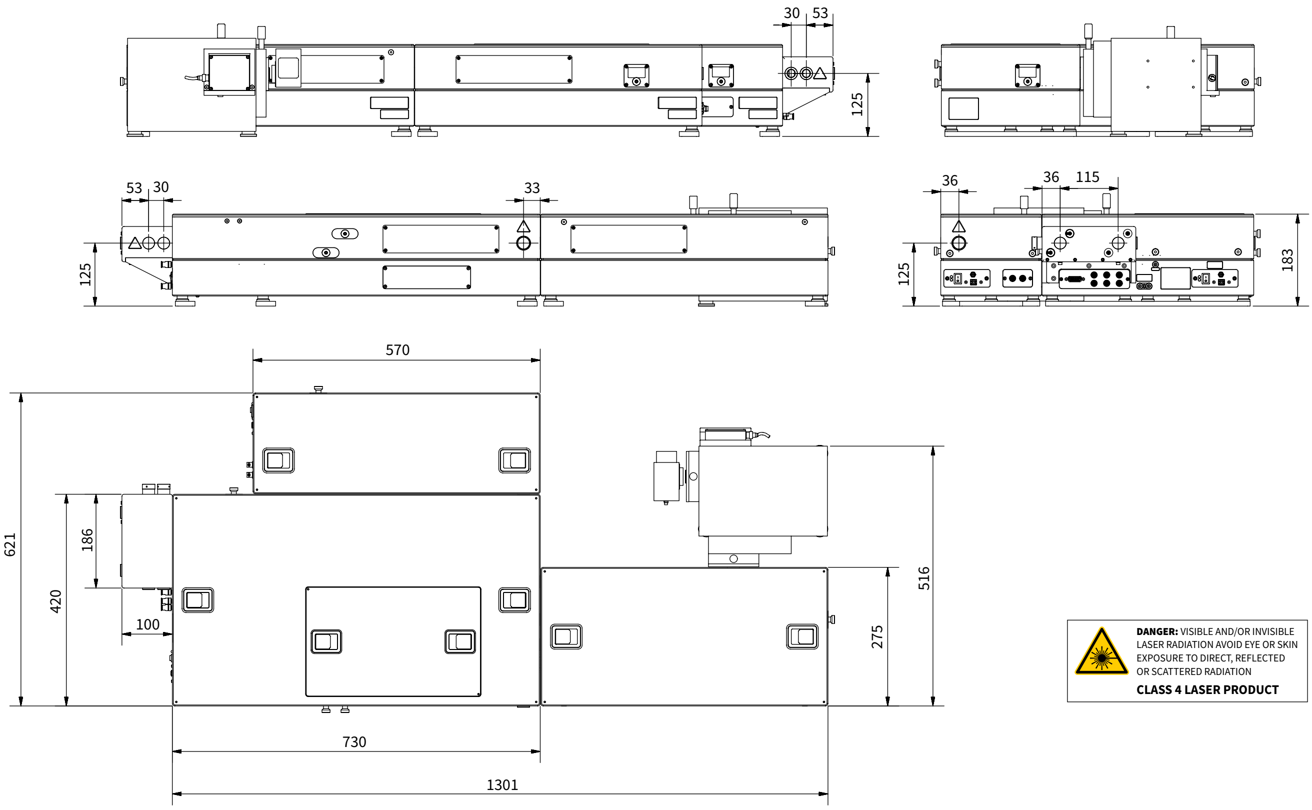


State transitions and pulse timing in multi-pulse time-resolved transient absorption spectroscopy



Femtosecond stimulated Raman scattering (FSRS)

DRAWINGS



Drawings of HARPIA system with HARPIA-TB and HARPIA-TF modules

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HARPIA | MM

Microscopy Module

FEATURES

- Sub-5 µm spatial resolution
- Broadband and monochromatic probe options
- Motorized XYZ sample stage
- Transmission, specular and diffuse reflection geometry

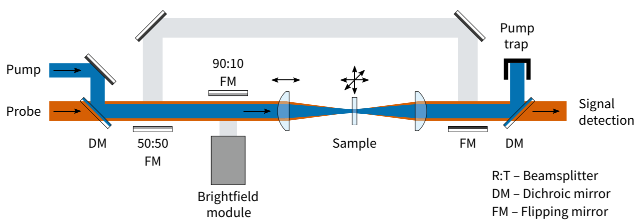
SPECIFICATIONS

Spatial resolution	5 µm
Working distance	15 mm
Spectral range	470 – 1100 nm
Temporal resolution	500 fs
Sample motion range	13 × 13 × 13 mm

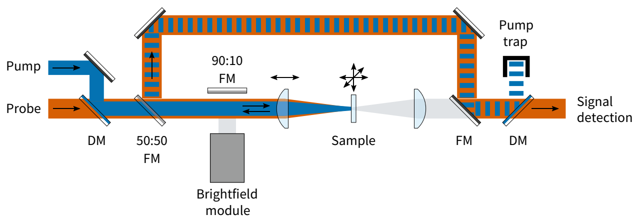
HARPIA-MM is a microscopy module add-on to the HARPIA spectrometer, which enables spatially-resolved pump-probe measurements with a sub-5 µm resolution. The sample can be positioned and scanned in a 13 mm range along XYZ axes using a motorized stage. Microscopic transient transmission and reflection signals can be measured using a broadband or a monochromatic probe. HARPIA-MM allows the acquisition of time-resolved spectra at a fixed position, difference absorption images at a fixed probe delay, and other types of data. Switching between bulk and microscopic pump-probe modes is implemented using self-contained modules, allowing experiment reconfiguration without disturbing the sample. The microscopy module features a brightfield mode to observe the sample and to determine the pump-probe spot location.

HARPIA with bulk (top) and microscopy (bottom) modules installed

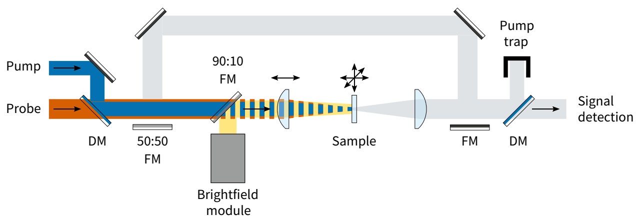
TRANSMISSION MODE



REFLECTION MODE



BRIGHTFIELD MODE



HARPIA Service App

System control and data acquisition software

A single software solution for all measurement modes, featuring:

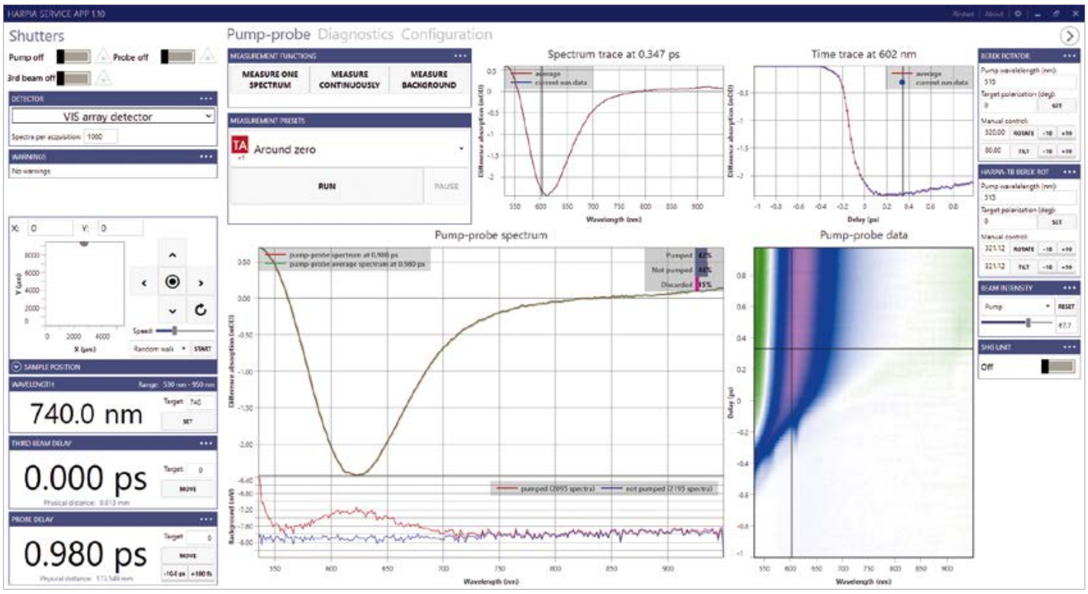
- Wizard-guided measurements and calibration
- Measurement presets
- Measurement noise suppression using data balancing and outlier detection
- Diagnostics and data export tools
- REST API for remote experiment control using third-party software

CarpetView

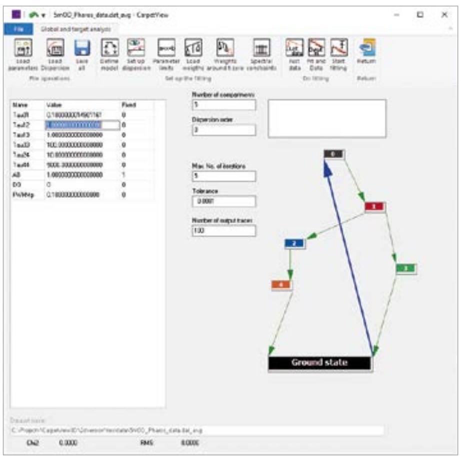
Data analysis software

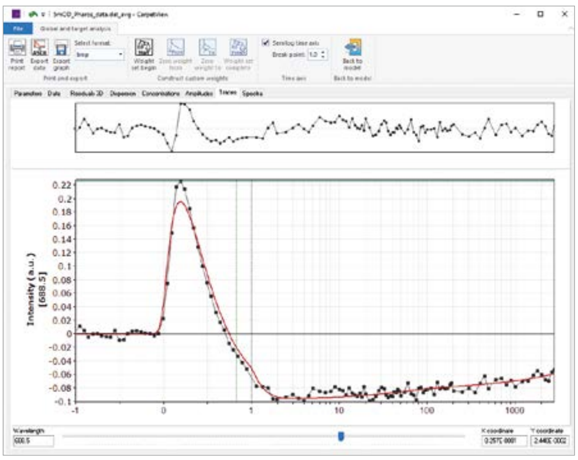
An ultrafast spectroscopy data analysis software, featuring:

- Publication-quality figure preparation and data export tools
- Advanced data wrangling: slicing, merging, cropping, shifting, smoothing, fitting, subtracting, etc.
- Probe spectral chirp correction, calibration and deconvolution
- Advanced global and target analysis
- Support for three-dimensional data sets (2D electronic spectroscopy, fluorescence lifetime imaging)



HARPIA Service App main window

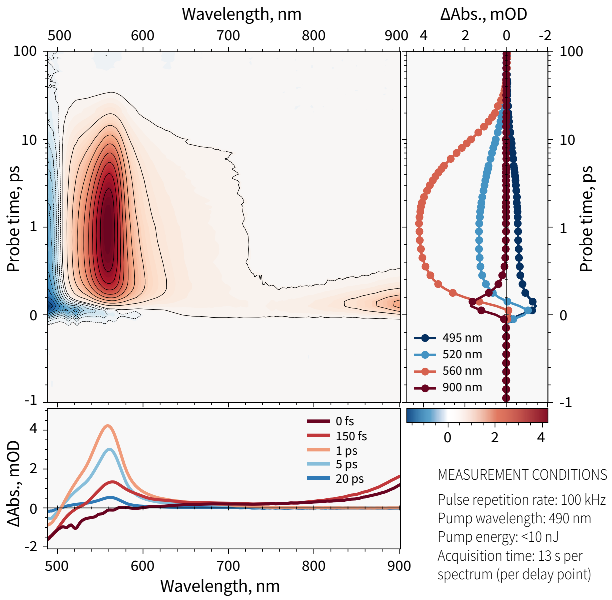




Global and target analysis windows of CarpetView

Examples of Scientific Applications

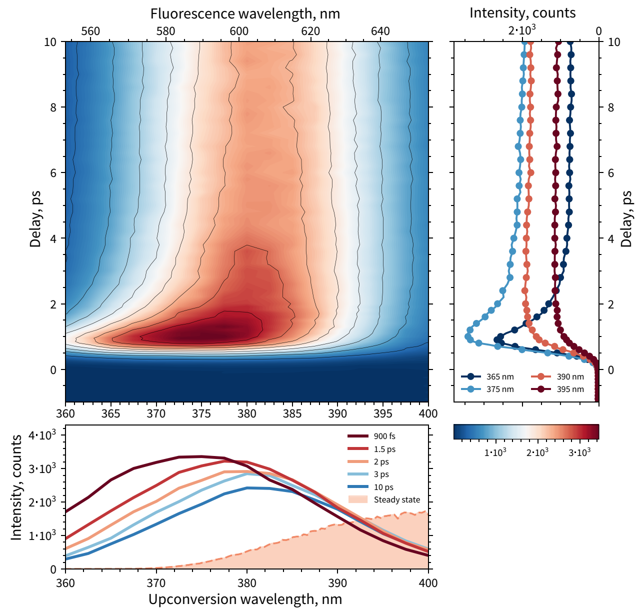
FEMTOSECOND PUMP-PROBE



MEASUREMENT CONDITIONS
Pulse repetition rate: 100 kHz
Pump wavelength: 490 nm
Pump energy: <10 nJ
Acquisition time: 13 s per spectrum (per delay point)

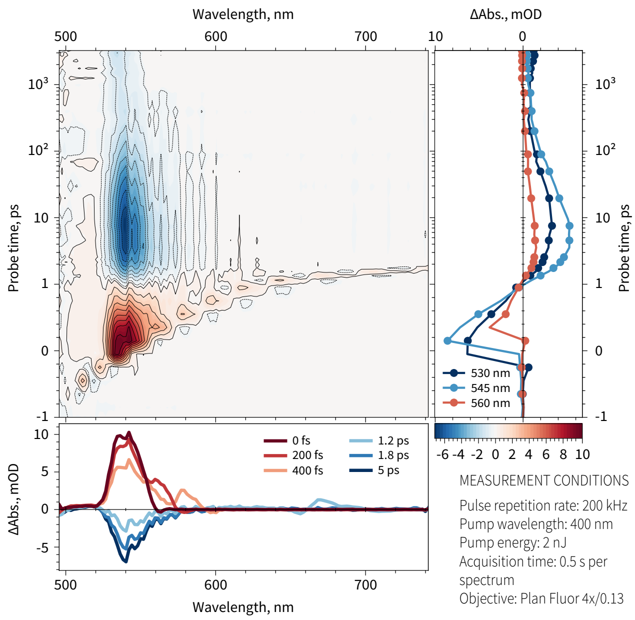
Spectral dynamics of beta-carotene in solution acquired using HARPIA-TA

FLUORESCENCE UPCONVERSION



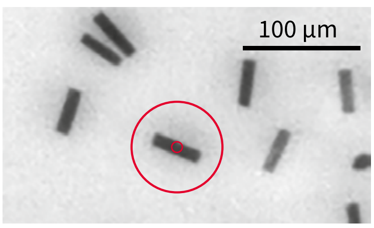
Fluorescence dynamics of DCM laser dye in solution acquired using HARPIA-TF in fluorescence upconversion mode

FEMTOSECOND PUMP-PROBE MICROSPECTROSCOPY



MEASUREMENT CONDITIONS
Pulse repetition rate: 200 kHz
Pump wavelength: 400 nm
Pump energy: 2 nJ
Acquisition time: 0.5 s per spectrum
Objective: Plan Fluor 4x/0.13

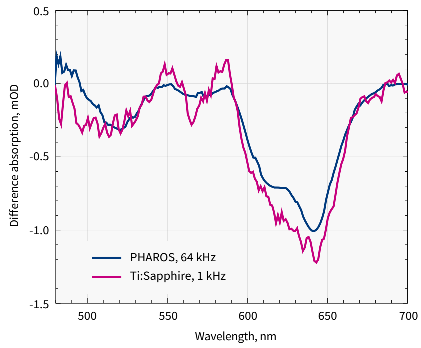
Single perovskite crystallite pump-probe spectral kinetics, pump at 400 nm



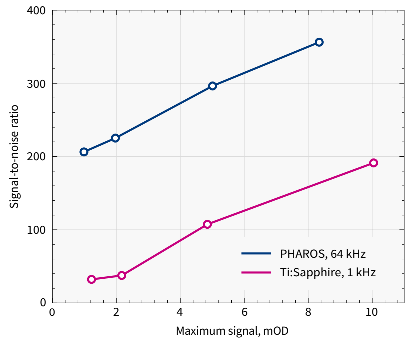
Pump-probe spot marked by the small circle

HARPIA PERFORMANCE AT HIGH REPETITION RATES

The HARPIA spectroscopy system achieves an excellent signal-to-noise ratio at high repetition rate and low energy excitation conditions. The graphs below compare the SNR of difference absorption spectra obtained with a Ti:Sapphire laser running at 1 kHz and a PHAROS laser running at 64 kHz with the same acquisition time.



Measured difference absorption spectra of CdSe/ZnS quantum dots using low- and high-repetition rate lasers with 5 s acquisition time



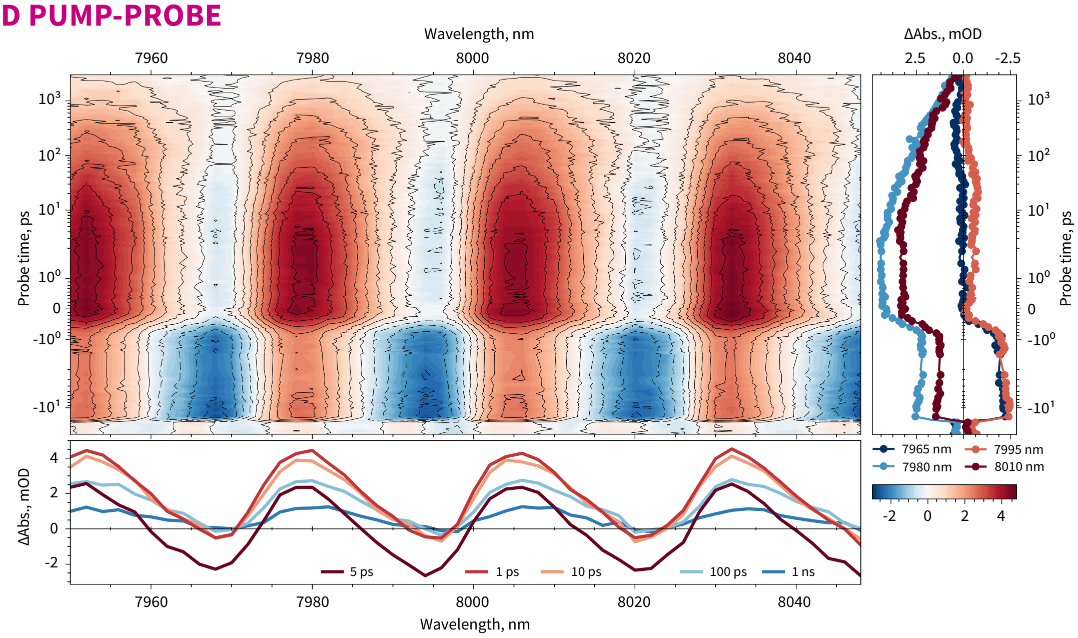
Best-effort signal-to-noise ratios, achieved with HARPIA-TA spectrometer driven by a Ti:Sapphire laser operating at 1 kHz (red) and a PHAROS laser operating at 64 kHz (blue)

IR FEMTOSECOND PUMP-PROBE

Pump-probe dynamics of GaAs wafer in IR measured using signal and reference single-channel detectors

MEASUREMENT CONDITIONS

Pulse repetition rate: 75 kHz
Pump wavelength: 700 nm
Acquisition time: 1 s per point

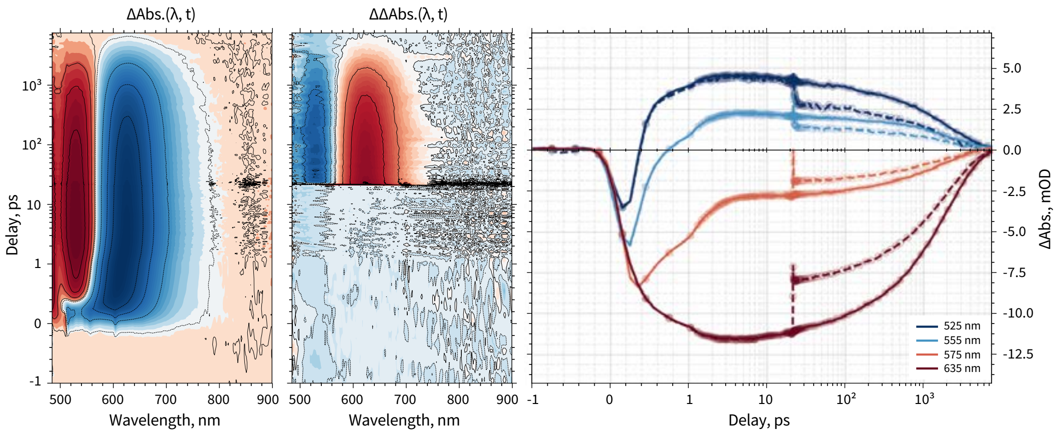


FEMTOSECOND PUMP-DUMP-PROBE

Pump-dump-probe dynamics of DCM laser dye with dump pulse resonant to the emission band of DCM

MEASUREMENT CONDITIONS

Pulse repetition rate: 50 kHz
Pump wavelength: 515 nm
Dump wavelength: 700 nm
Dump delay: 21 ps
Pump energy: 90 nJ
Dump energy: 190 nJ

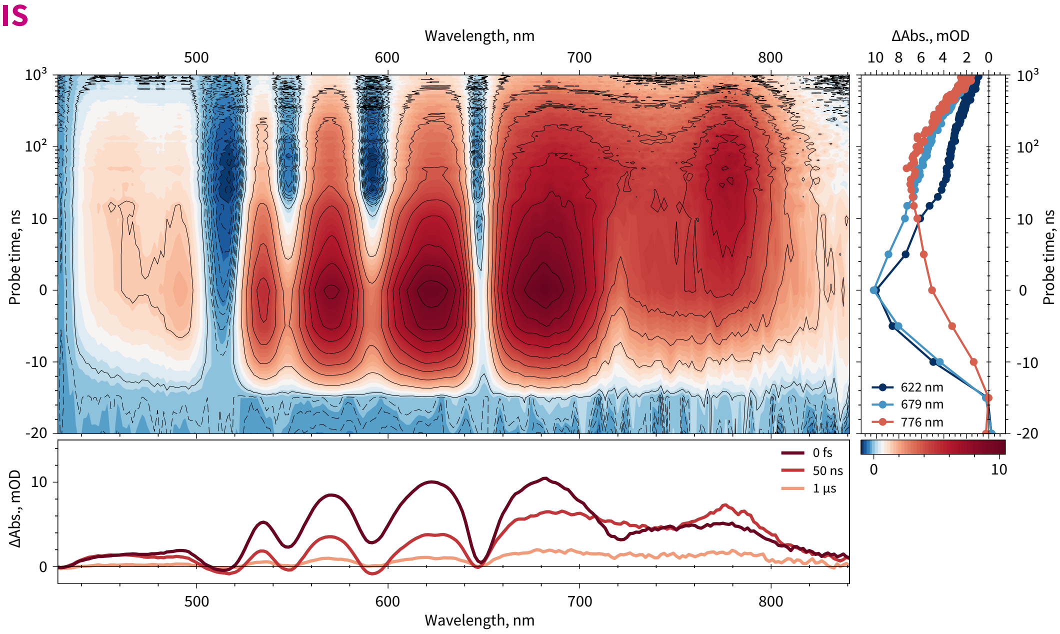


FLASH PHOTOLYSIS

Nanosecond spectral dynamics of meso-Tetraphenylporphine in solution acquired using HARPIA in flash photolysis mode

MEASUREMENT CONDITIONS

Pulse repetition rate: 1.8 kHz
Pump wavelength: 343 nm
Pump energy: 5.4 µJ



GECO

Scanning Autocorrelator

FEATURES

- 10 fs – 20 ps pulse duration range
- 500 – 2000 nm wavelength range
- High-resolution voice coil driven delay line
- Integrated controller and computer
- Compact and portable design
- Pulse-analysis software
- FROG-ready

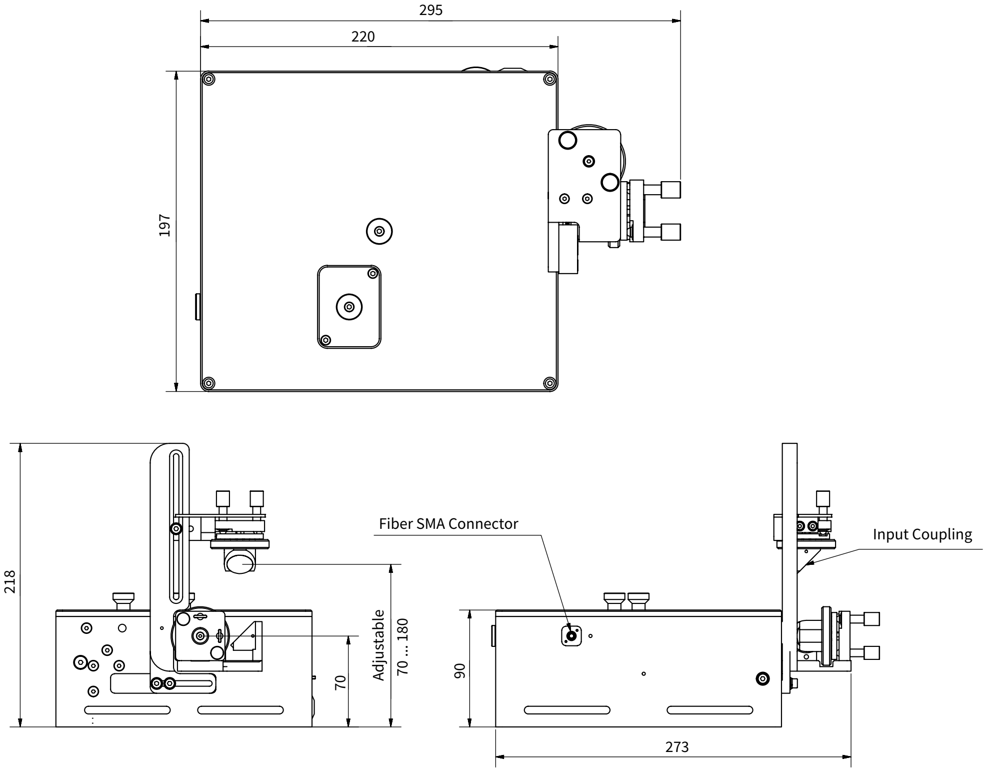
GECO is a scanning autocorrelator designed for pulse duration measurements of systems with ≥ 1 kHz repetition rate. Operation of GECO is based on noncollinear second-harmonic generation in a nonlinear crystal, producing intensity autocorrelation trace directly related to the input beam pulse duration. One arm of the fundamental pulse is delayed by a linear positioning stage, providing fast, reliable motion with 0.13 fs resolution. GECO can acquire a full intensity autocorrelation trace of 10 fs – 20 ps pulses and covers the 500 – 2000 nm wavelength range. GECO features noncollinearity angle adjustment and can be transformed into a collinear setup, allowing the performance of interferometric autocorrelation measurements for pulses in the 10 fs range. GECO comes with an integrated computer and pulse-analysis software. It is also capable of generating FROG traces, if an external spectrometer is connected. Software APIs are available for custom user adaptations.

SPECIFICATIONS

Input wavelength range		500 – 2000 nm
Input pulse duration		10 – 20000 fs
Minimum repetition rate		1 kHz
Minimum input power	from amplifiers	2 – 200 mW @ 1 – 1000 kHz
	from oscillators	800 nm, 100 fs: > 400 mW @ 75 MHz 1030 nm, 100 fs: > 250 mW @ 75 MHz
Temporal resolution		0.13 fs / step
Scan rate		5 scans/s @ 1 – 1000 kHz
Detector		Si photodiode

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

DRAWINGS



GECO drawings

TIPA

Single-Shot Autocorrelator

FEATURES

- 30 fs – 1 ps pulse duration range
- 500 – 2000 nm wavelength range
- Pulse-front tilt measurements
- High-speed 12-bit CCD camera
- Non-collinear intensity and collinear interferometric autocorrelation traces
- Non-dispersive polarization control
- Compact and portable design
- Pulse-analysis software

TIPA is a single-shot autocorrelator for pulse-front tilt and pulse duration measurements of systems with ≤ 1 kHz repetition rate. Its unique design allows monitoring and measuring of the pulse duration as well as the pulse front tilt in both vertical and horizontal planes. Operation of TIPA is based on non-collinear second harmonic (SH) generation, where the spatial distribution of the SH beam contains information on the temporal shape of the fundamental pulse. The basic idea is that two replicas of a fundamental ultrashort pulse pass non-collinearly through a nonlinear crystal, in which SH generation takes place. The SH beam width and tilt in a plane perpendicular to propagation provide information about the pulse duration and pulse front tilt.

This technique combines low background and single-shot measurement capabilities. The CCD camera carries out the SH beam sampling. TIPA comes with user-friendly software for direct monitoring of pulse properties.

SPECIFICATION

Model [1]		AT1C1	AT2C1	AT5C3
PERFORMANCE				
Input wavelength range		700 – 900 nm	900 – 1100 nm	500 – 2000 nm
Input pulse duration		30 – 1000 fs		
Minimum repetition rate		Single-shot		
Minimum input power	from amplifiers	Integration mode: 5 – 200 mW @ 1 – 1000 kHz Single-shot mode: 30 – 200 µJ		
	from oscillators	800 nm, < 100 fs: > 500 mW @ 75 MHz 1030 nm, < 100 fs: > 300 mW @ 75 MHz		
Temporal resolution		500 fs/mm		
Detector		CCD (1296 × 964 resolution, 3.75 µm pixel, 12 bits)		

[1] *Non-standard models are available on request.*

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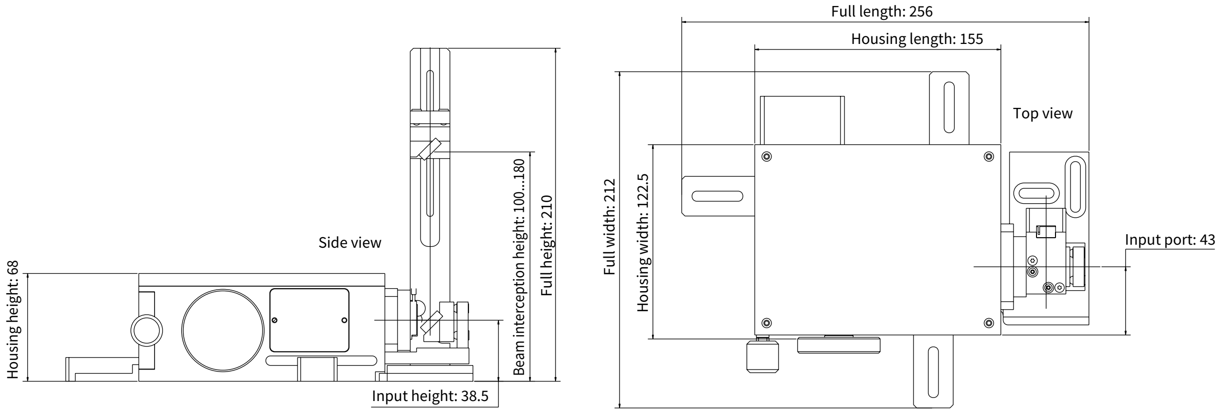
CLASS 4 LASER PRODUCT

DRAWINGS



TIPA drawings

LIGHT
CONVERSION

www.gmp.ch

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