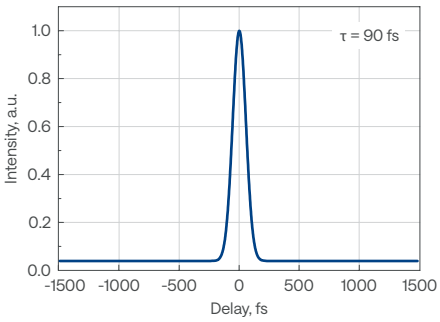
PHAROS

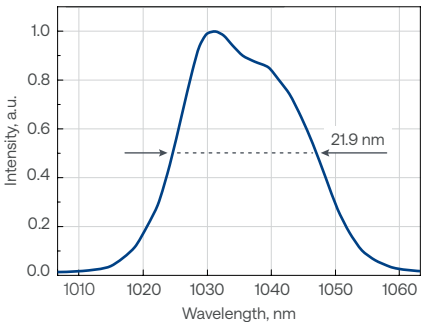
Modular-Design Femtosecond Lasers for Industry and Science

- Tunable pulse duration, 100 fs – 20 ps
- Maximum pulse energy of up to 4 mJ
- Down to < 100 fs right at the output
- Pulse-on-demand and BiBurst for pulse control
- Up to 5th harmonic or tunable extensions
- CEP stabilization or repetition rate locking
- Thermally-stabilized and sealed design

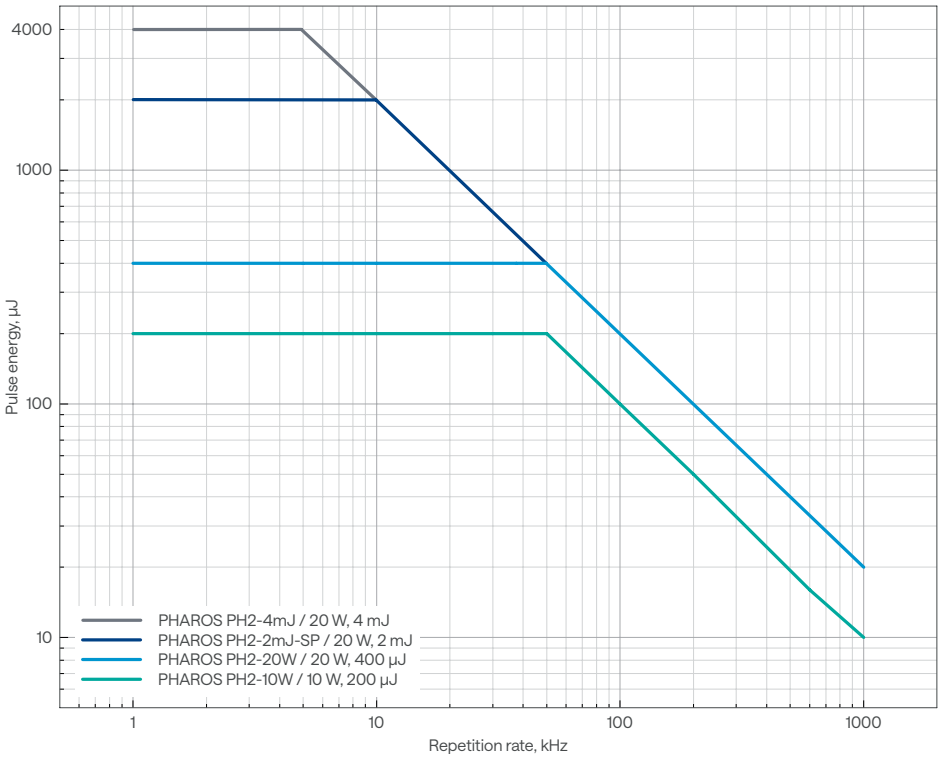
PHAROS-PH2-UP
Typical pulse duration



PHAROS-PH2-UP
Typical spectrum



PHAROS
Pulse energy vs fundamental repetition rate



Specifications

Model	PH2-10W	PH2-20W-SP			PH2-4mJ	PH2-UP
OUTPUT CHARACTERISTICS						
Center wavelength [1]	1030 ± 10 nm					
Maximum output power	10 W	20 W				
Pulse duration [2]	< 290 fs	< 190 fs			< 450 fs [3]	< 100 fs
Pulse duration tuning range	290 fs – 10 ps (20 ps on request)	190 fs – 10 ps (20 ps on request)			450 fs – 10 ps	100 fs – 10 ps
Maximum pulse energy	0.2 mJ	0.4 mJ	1 mJ	2 mJ	4 mJ	0.4 mJ
Repetition rate	Single-shot – 1 MHz					
Pulse selection	Single-shot, pulse-on-demand, any fundamental repetition rate division					
Polarization	Linear, horizontal					
Beam quality, M^2	< 1.2	< 1.3				< 1.2
Beam diameter [4]	3.3 ± 0.5 mm	4.0 ± 0.5 mm	4.5 ± 0.5 mm	6.8 ± 0.7 mm		4.5 ± 0.5 mm
Beam pointing stability	< 20 µrad/°C					
Pre-pulse contrast	< 1 : 1000					
Post-pulse contrast	< 1 : 200					
Pulse-to-pulse energy stability, 24 h [5]	< 0.5%					
Long-term power stability, 100 h [5]	< 0.5%					
MAIN OPTIONS						
Oscillator output [6]	1 – 7 W, 50 – 250 fs, ≈ 1035 nm, ≈ 76 MHz					
Harmonic generator [7]	515 nm, 343 nm, 257 nm, or 206 nm; *see page 23*					
Optical parametric amplifier [8]	320 – 10000 nm; *see page 30*					
BiBurst option	Tunable GHz and MHz burst with burst-in-burst capability; *see page 13*					
CEP stabilization	*See page 17*					
Repetition rate locking						
PHYSICAL DIMENSIONS						
Laser head (L × W × H) [9]	730 × 419 × 230 mm				827 × 492 × 250 mm	730 × 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 – Laser	100 V AC, 12 A – 240 V AC, 5 A, 50 – 60 Hz					
Electrical requirements – Chiller	100 – 230 V AC, 50 – 60 Hz					
Rated power – Laser	1000 W					
Rated power – Chiller	1400 W					
Power consumption – Laser	600 W					
Power consumption – Chiller	1000 W					

[1] *Precise wavelengths for specific models are available upon request.*

[2] *Assuming Gaussian pulse shape.*

[3] *Pulse duration can be reduced to < 250 fs if pulse peak intensity of > 50 GW/cm² is tolerated by the customer setup.*

[4] *FW 1/e², measured at laser output, using maximum pulse energy.*

[5] *Under stable environmental conditions. Expressed as normalized root mean squared deviation (NRMSD).*

[6] *Available simultaneously. Contact sales@lightcon.com for more details or customized solutions.*

[7] *Integrated. For external harmonic generator, refer to HIRO.*

[8] *Integrated. For more options and OPAs for -4mJ and -UP models, refer to www.lightcon.com.*

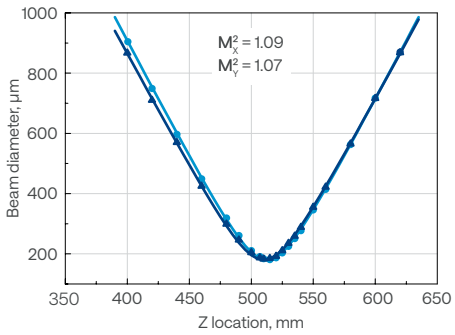
[9] *Dimensions depend on laser configuration and integrated options.*

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

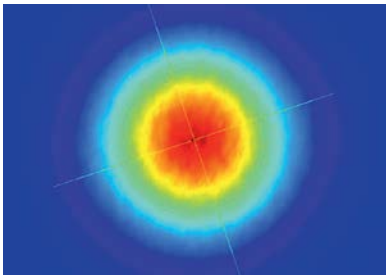
CLASS 4 LASER PRODUCT

Beam properties

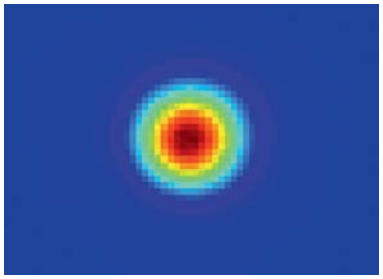
PHAROS
Typical M^2 measurement data



PHAROS
Typical near-field beam profile

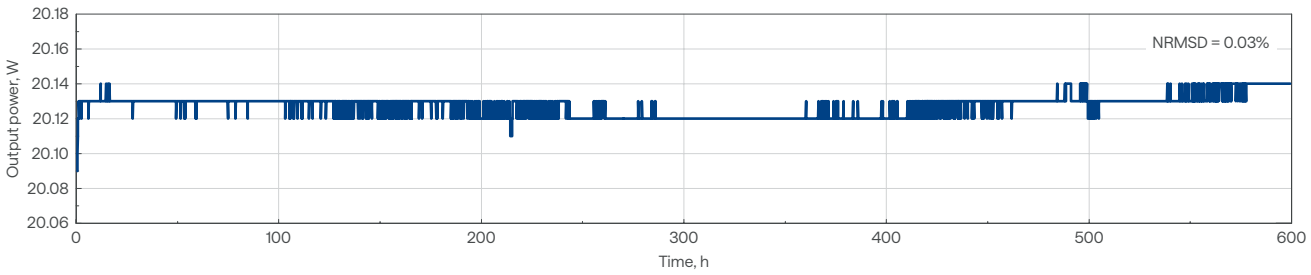


PHAROS
Typical far-field beam profile

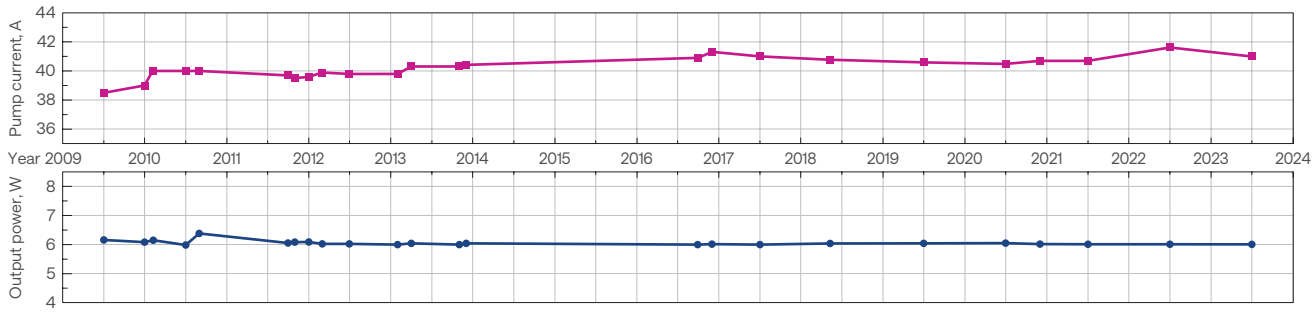


Stability measurements

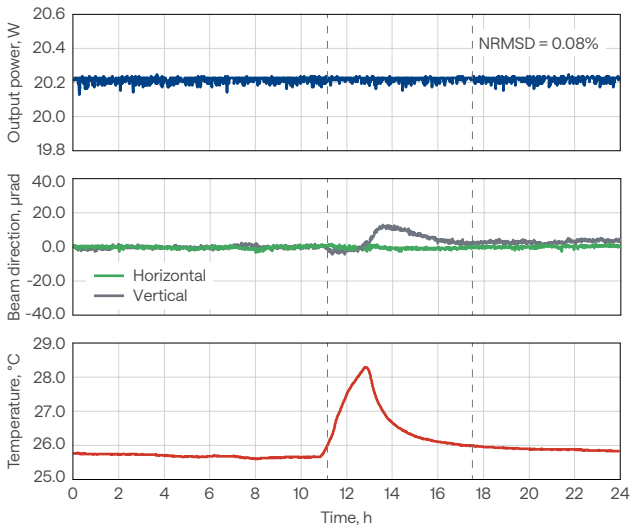
PHAROS
Long-term power stability



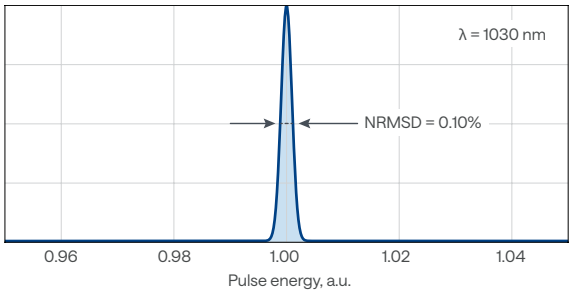
Output power of industrial-grade **PHAROS** lasers operating 24/7 and the current of the pump diodes over the years



PHAROS output power and the stability of beam direction with power lock enabled, across varying environmental conditions



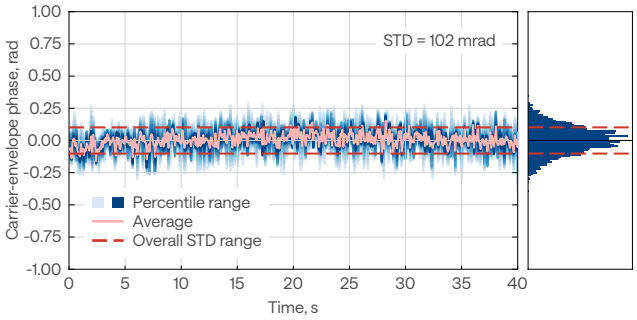
PHAROS
Typical pulse-to-pulse energy stability



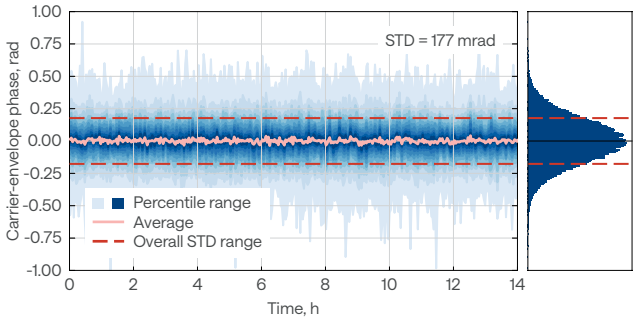
CEP stabilization

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.

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



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

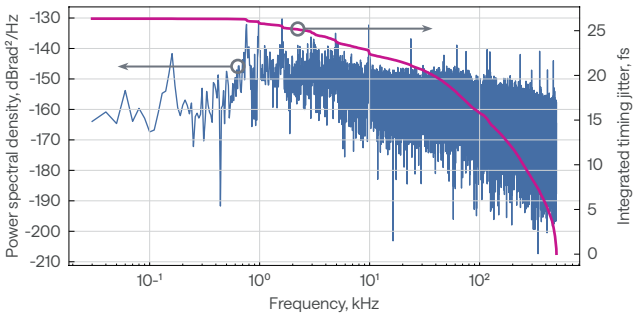


Repetition rate locking

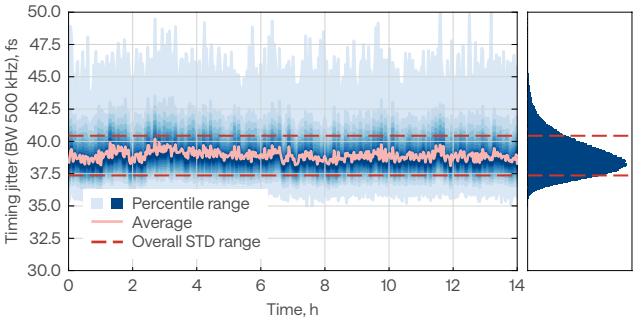
The oscillator of **PHAROS** laser can be customized for repetition rate locking applications. Coupled with the necessary feedback electronics, the repetition rate is synchronized to an external RF source using the two piezo stages installed inside the cavity.

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

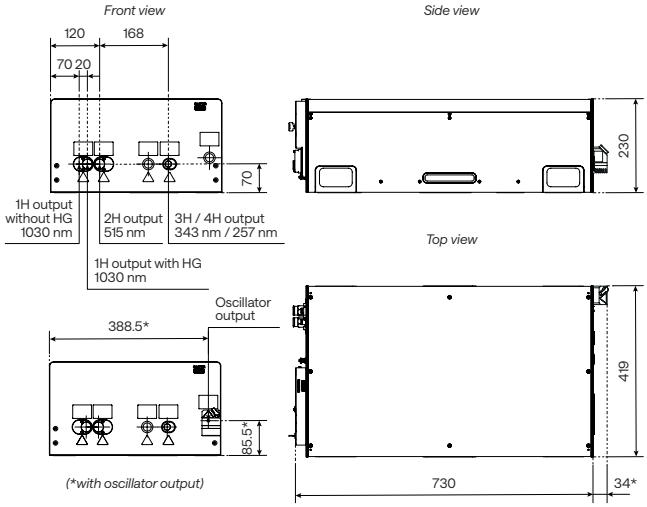


Timing jitter stability over 14 h
PHAROS oscillator locked to a 2.8 GHz RF source

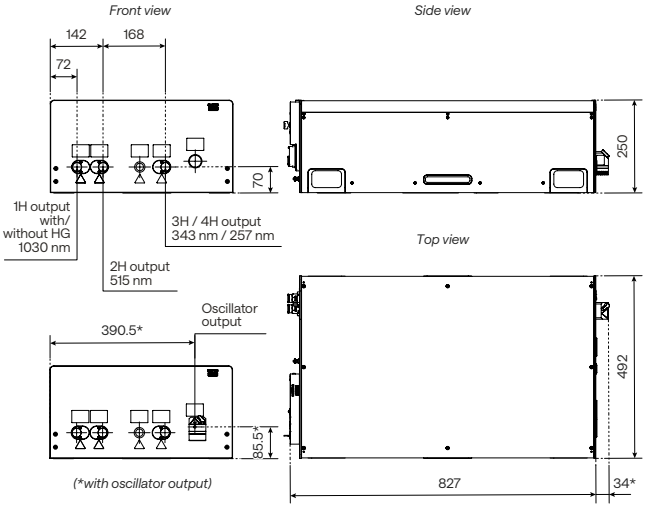


Drawings

PHAROS-PH2-730 drawing.
PH2 or PH2-SP with FEC, BiBurst, or harmonics;
also, PH2-UP without harmonics



PHAROS-PH2-827 drawing
PH2 with -HE harmonics, PH2-4mJ, or PH2-UP with harmonics



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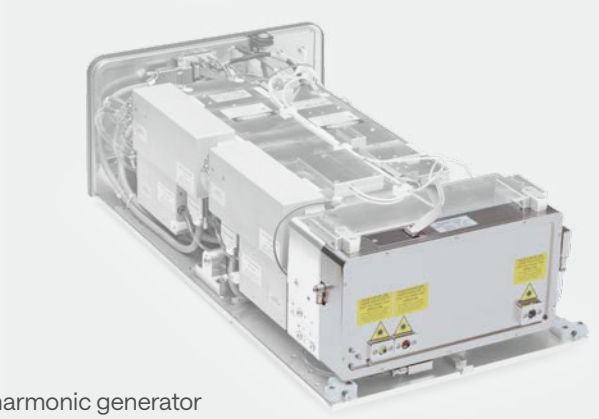
HG | PHAROS

Automated Harmonic Generators



PHAROS with a harmonic generator

- 515 nm, 343 nm, 257 nm, or 206 nm output
- Automated harmonic selection
- Industrial-grade design

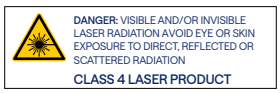
Specifications

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 – 4000 µJ	50 – 4000 µJ	20 – 4000 µJ	200 – 1000 µJ
Pump pulse duration		100 – 500 fs			
Conversion efficiency		> 50% (2H)	> 50% (2H) > 25% (3H)	> 50% (2H) > 10% (4H) [2]	> 10% (4H) [2] > 5% (5H) [3]
Beam quality, M^2, typical values	≤ 400 µJ pump	<1.15 (2H)	<1.15 (2H) <1.2 (3H)	<1.15 (2H) n/a (4H)	n/a
	> 400 µJ pump	<1.2 (2H)	<1.2 (2H) <1.3 (3H)	<1.2 (2H) n/a (4H)	

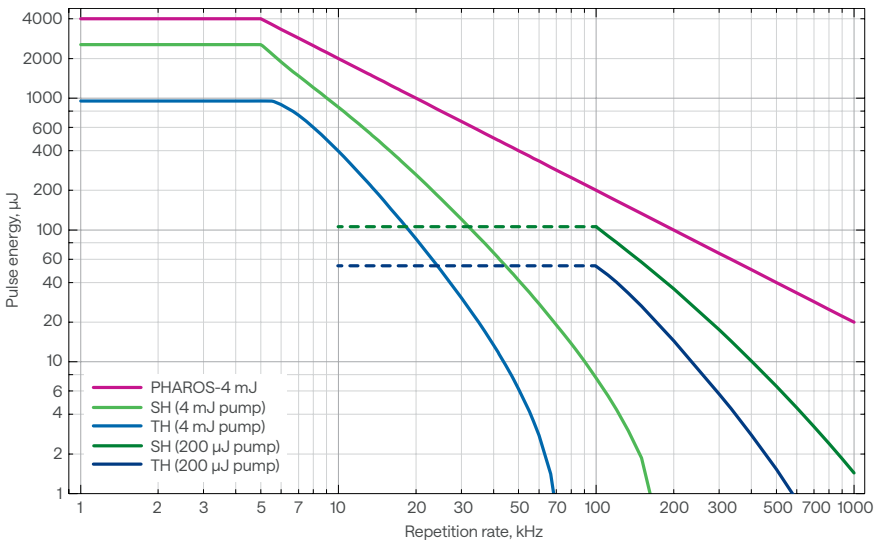
[1] *Depends on pump laser model.*

[2] *Maximum output power of 2 W at 20 – 1000 µJ pump or 1 W at 1000 – 4000 µJ pump.*

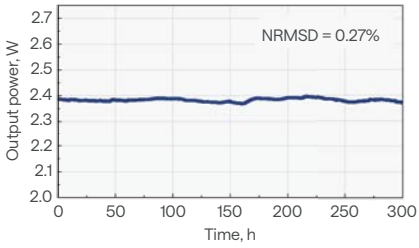
[3] *Maximum output power of 150 mW.*



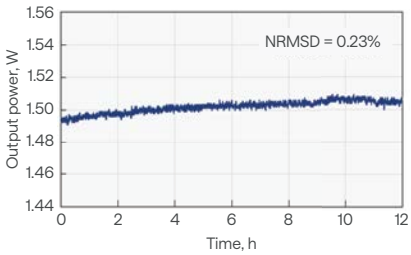
PHAROS with HG pulse energy vs repetition rate



3H output power stability



4H output power stability



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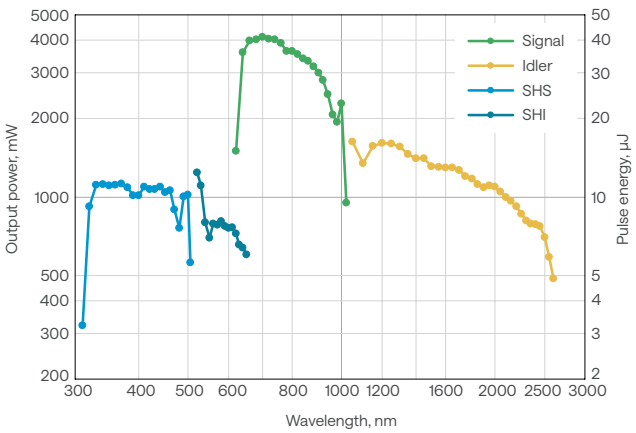
I-OPA

Industrial-Grade Optical Parametric Amplifier

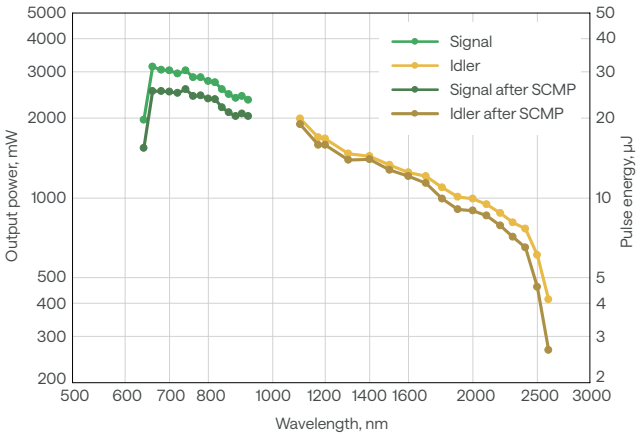
I-OPA-TW on air-cooled CARBIDE-CB5

- Wavelength tunability in an industrial design
- Single-box solution
- Tunable or fixed-wavelength models
- Plug-and-play installation and robust performance
- The most compact OPA in the market

I-OPA-HP typical tuning curves
Pump: 40 W, 400 µJ, 100 kHz



I-OPA-F typical tuning curves
Pump: 40 W, 400 µJ, 100 kHz



Specifications

Model	I-OPA-HP	I-OPA-F	I-OPA-ONE
Configuration	ORPHEUS	ORPHEUS-F	ORPHEUS-ONE
Pump power	Up to 40 W		
Pump pulse energy	20 – 400 µJ		
Repetition rate	Up to 2 MHz		
Tuning range [1]	640 – 1010 nm (signal) 1050 – 2600 nm (idler)	650 – 920 nm (signal) 1200 – 2500 nm (idler)	1350 – 2000 nm (signal) 2100 – 4500 nm (idler)
Conversion efficiency	> 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 (20 – 40 µJ pump; up to 2 MHz)		> 6% @ 1550 nm (20 – 40 µJ pump; up to 2 MHz)
Spectral bandwidth [2]	80 – 220 cm^{-1} @ 700 – 960 nm	200 – 1000 cm^{-1} @ 650 – 920 nm 150 – 1000 cm^{-1} @ 1200 – 2000 nm	60 – 150 cm^{-1} @ 1450 – 2000 nm
Pulse duration [2] [3]	120 – 250 fs	< 55 fs @ 800 – 920 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	100 – 300 fs
Long-term power stability, 8 h [4]	< 1% @ 800 nm		< 1% @ 1550 nm
Pulse-to-pulse energy stability, 1 min [4]	< 1% @ 800 nm		< 1% @ 1550 nm
Wavelength extension options	320 – 505 nm (SHS) [5] 525 – 640 nm (SHI) [5]	Contact sales@lightcon.com	4500 – 10000 nm (DFG)
Pulse compression options [2]	n/a	SCMP (signal pulse compressor) ICMP (idler pulse compressor) GDD-CMP (compressor with GDD control)	n/a

PUMP LASER REQUIREMENTS

Pump laser	PHAROS or CARBIDE
Center wavelength	1030 ± 10 nm
Maximum pump power	40 W
Maximum repetition rate	Up to 2 MHz
Pump pulse energy	20 – 400 µJ
Pulse duration	180 – 300 fs

ENVIRONMENTAL & UTILITY REQUIREMENTS

Operating temperature [6]	19 – 25 °C (air conditioning recommended)
Relative humidity [6]	20 – 70% (non-condensing)
Electrical requirements	n/a [7]

[1] *In case of fixed wavelength (FW), a single wavelength can be selected from the signal or idler range. The signal may have an accessible idler pair, and vice versa.*

[2] *I-OPA-F broad-bandwidth pulses are compressed externally. Typical pulse duration before compression: 120 – 250 fs, after compression: 25 – 70 fs @ 650 – 900 nm, 40 – 100 fs @ 1200 – 2000 nm.*

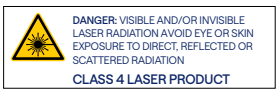
[3] *Output pulse duration depends on selected wavelength and pump laser pulse duration.*

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

[5] *Conversion efficiency is 1.2% at peak; specified as a percentage of pump power.*

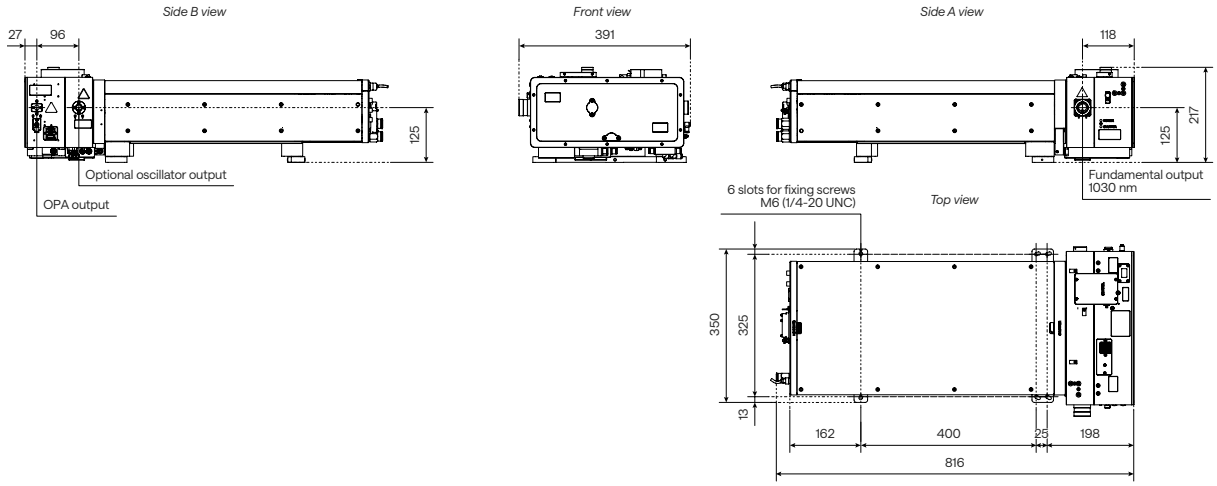
[6] *Specifications are guaranteed for a maximum temperature variation of ± 1 °C and humidity variation of ± 10%.*

[7] *I-OPA is powered by the same electrical source as the pump laser. Thus, refer to the pump laser electrical requirements.*

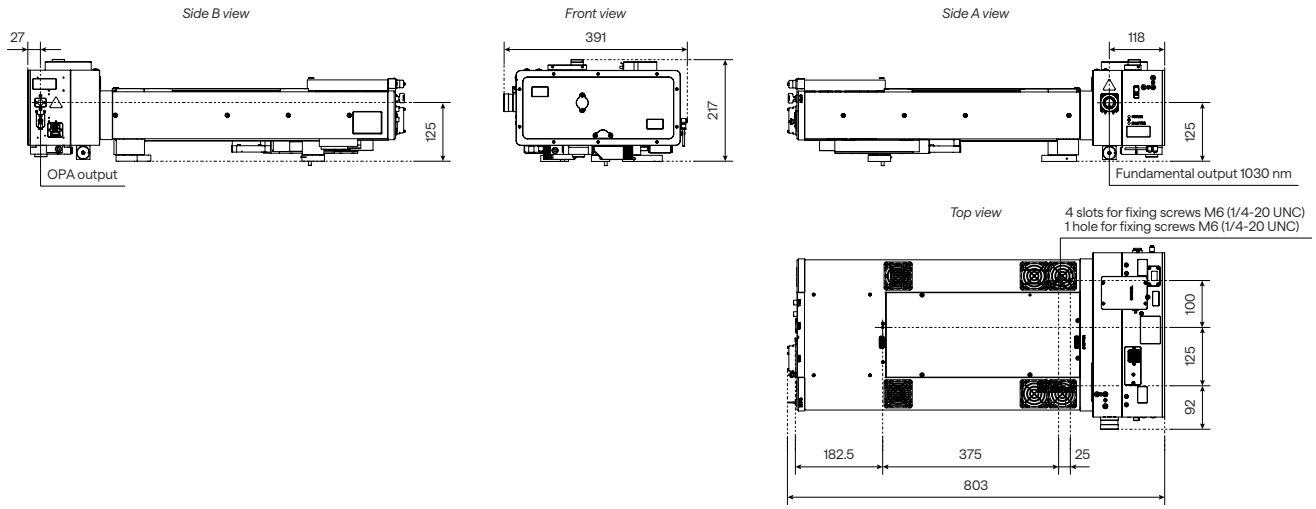


Drawings

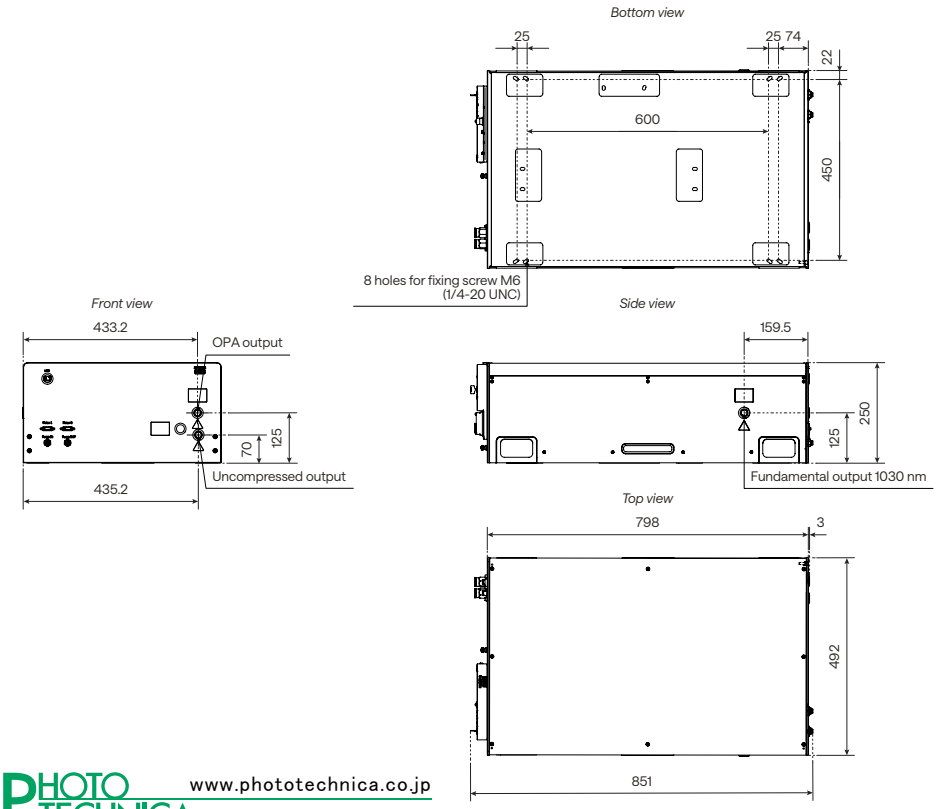
CARBIDE-CB3 with **I-OPA-HP** drawing and output ports



CARBIDE-CB5 with **I-OPA-HP** drawing and output ports



PHAROS-PH2 with **I-OPA-HP** drawing and output ports



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BiBurst | OPTION

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

PHAROS and **CARBIDE-CB3** lasers offer an option for tunable GHz and MHz burst with burst-in-burst capability, known as BiBurst.

In standard mode, a single pulse is emitted at a fixed frequency. In burst mode, the output consists of pulse packets rather than single pulses. Each packet comprises a certain number of equally spaced pulses. MHz-Burst contains N pulses with a nanosecond period, while GHz-Burst contains P pulses with a picosecond period. When both GHz and MHz burst modes are used simultaneously, the equally spaced pulse packets contain sub-packets of pulses, known as burst-in-burst or BiBurst.

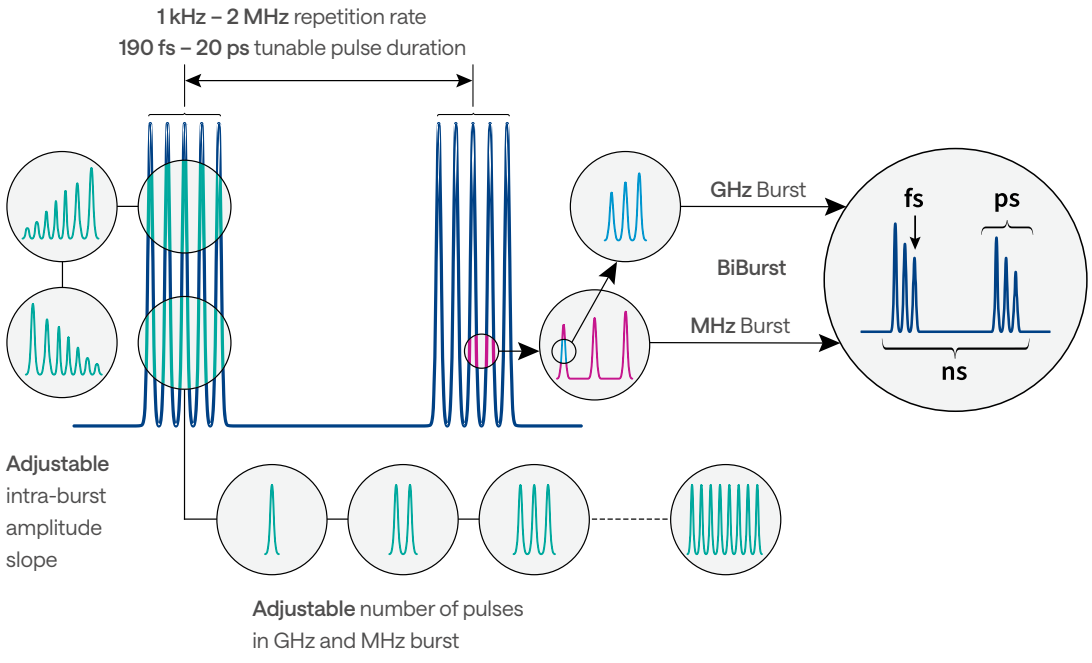
PHAROS and **CARBIDE** lasers with the BiBurst option bring new capabilities to high-tech manufacturing industries such as consumer electronics, integrated photonic chip manufacturing, future display manufacturing, and quantum technologies. The applications include:

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

Specifications

Model		CARBIDE-CB3	PHAROS
GHz Burst	Intra burst pulse period [1]	440 ± 40 ps	200 ± 40 ps
	Number of pulses, P [2]	1 – 10 [3]	1 – 25
MHz Burst	Intra burst pulse period	≈ 15 ns	
	Number of pulses, N	1 – 10	1 – 9 (7 with FEC [4])

[1] *Custom spacing is available upon request.*
[2] *The maximum number of pulses in a burst depends on the laser repetition rate and energy.*
[3] *A custom number of pulses (up to 400) is available upon request.*
[4] *Fast energy control option. Enables the formation of any pulse envelope at the laser pulse repetition rate.*



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