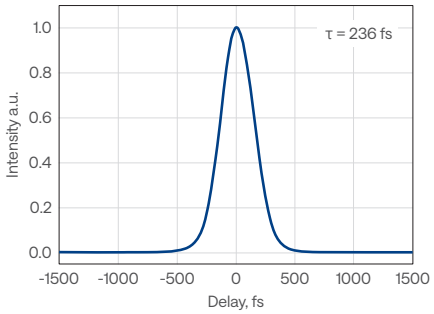
# PHAROS

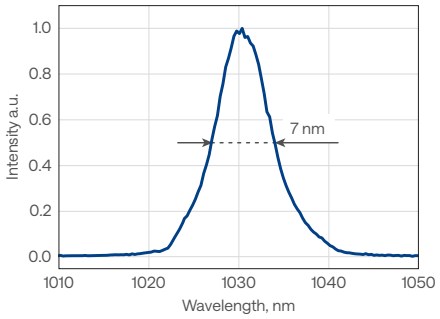
## High-Energy Femtosecond Lasers

- NEW Maximum pulse energy of up to 5 mJ
- Down to < 100 fs right at the output
- Tunable pulse duration, 100 fs – 20 ps
- Pulse-on-demand and BiBurst for pulse control
- Automated harmonics up to the 5th and wavelength-tunable extensions

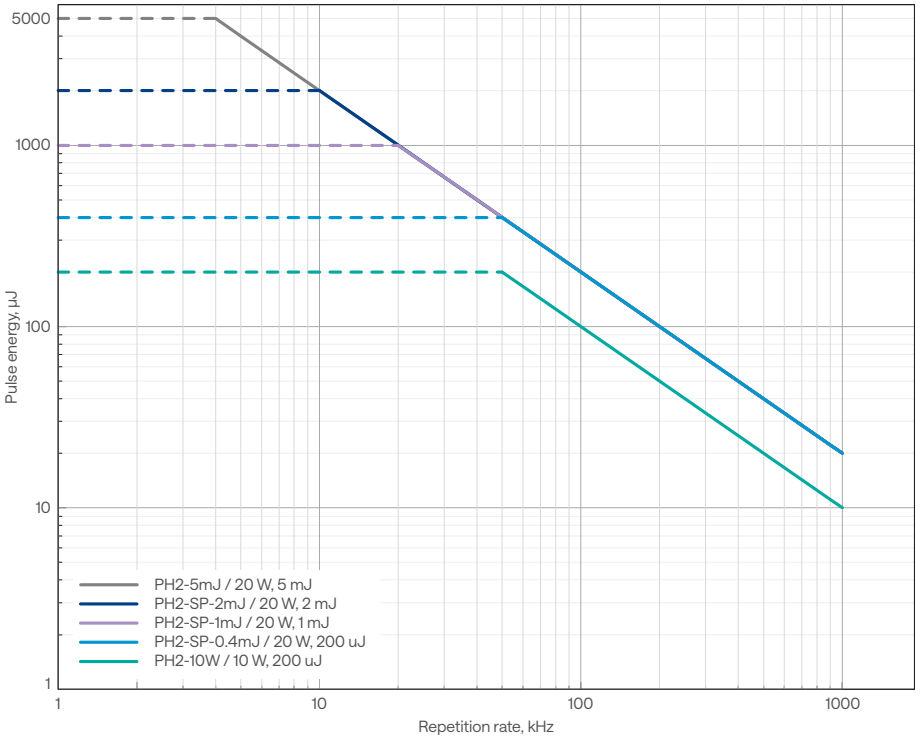

**PHAROS-PH2-5mJ**
Typical pulse duration




**PHAROS-PH2-5mJ**
Typical spectrum




**PHAROS**
Pulse energy vs fundamental repetition rate



# Specifications

NEW

| Model | PH2-10W | PH2-SP | | | PH2-5mJ | PH2-UP | |
|---|---|---|---|---|---|---|---|
| **OUTPUT CHARACTERISTICS** | | | | | | | |
| Center wavelength [1] | 1030 ± 10 nm | | | | | | |
| Maximum output power | 10 W | 20 W | | | | | |
| Pulse duration [2] | < 290 fs | < 190 fs | | | < 250 fs | < 100 fs | |
| Pulse duration tuning range | 290 fs – 10 ps (20 ps on request) | 190 fs – 10 ps (20 ps on request) | | | n/a | 100 fs – 10 ps | |
| Maximum pulse energy | 0.2 mJ | 0.4 mJ | 1 mJ | 2 mJ | 5 mJ | 0.4 mJ | 1 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 [3] | 3.3 ± 0.5 mm | 4.0 ± 0.5 mm | 4.5 ± 0.5 mm | 6.8 ± 0.7 mm | 11 ± 0.5 mm | 4.5 ± 0.5 mm | 6 ± 0.5 mm |
| Beam pointing stability | < 20 µrad/°C | | | | | | |
| Pre-pulse contrast | < 1 : 1000 | | | | | | |
| Post-pulse contrast | < 1 : 200 | | | | | | |
| Pulse-to-pulse energy stability, 12 h [4] | < 0.5% | | | | | | |
| Long-term power stability, 100 h [4] | < 0.5% | | | | | | |
| **MAIN OPTIONS** | | | | | | | |
| Oscillator output [5] | 1 – 7 W, 50 – 250 fs, ≈ 1035 nm, ≈ 76 MHz | | | | | | |
| Harmonic generator [6] | 515 nm, 343 nm, 257 nm, or 206 nm; see PHAROS HG (page 19) or HIRO (page 24) | | | | | | |
| Optical parametric amplifier [7] | UV – MIR; see I-OPA (page 30) or ORPHEUS (page 32) | | | | | | |
| BiBurst option | Tunable GHz and MHz burst with burst-in-burst capability; see BiBurst (page 14) | | | | | | |
| CEP stabilization | See CEP & RRL Option (page 18) | | | | | | |
| Repetition rate locking | | | | | | | |
| **PHYSICAL DIMENSIONS** | | | | | | | |
| Laser head (L × W × H) [8] | 730 × 419 × 230 mm | | | | 827 × 492 × 250 mm | 770 × 419 × 230 mm | |
| Chiller (L × W × H) | 590 × 484 × 267 mm | | | | | | |
| 24 V DC power supply (L × W × H) [8] | 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 a Gaussian pulse shape.*

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

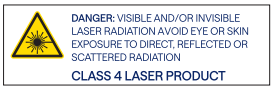
[4] *Under stable environmental conditions. Expressed as normalized root mean squared deviation (NRMSD).*

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

[6] *Integrated except for PH2-5mJ. For an external harmonic generator, see HIRO (page 24).*

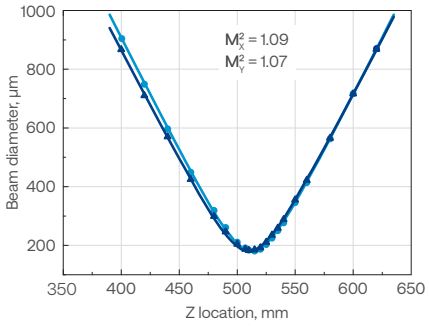
[7] *Integrated except for PH2-5mJ. For more options and OPAs for -5mJ and -UP models, see the ORPHEUS series of OPAs (page 32).*

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

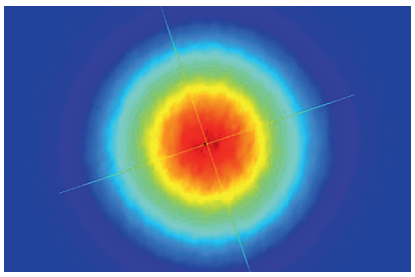


# Beam properties

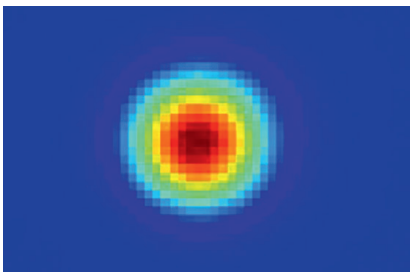
**PHAROS**
Typical $M^2$ measurement data




**PHAROS**
Typical near-field beam profile

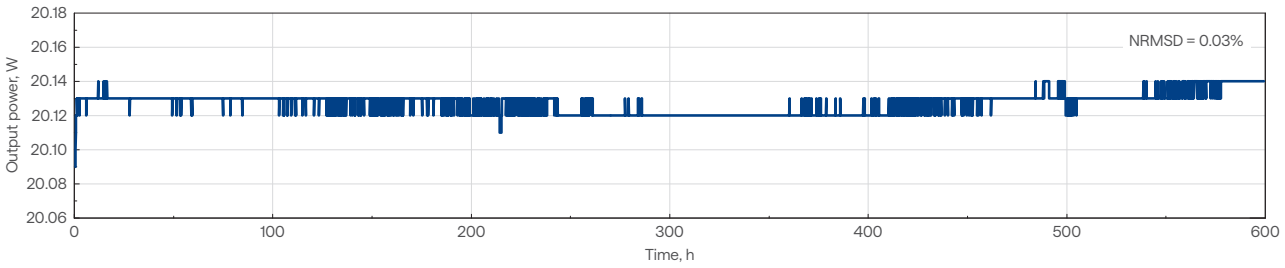


**PHAROS**
Typical far-field beam profile

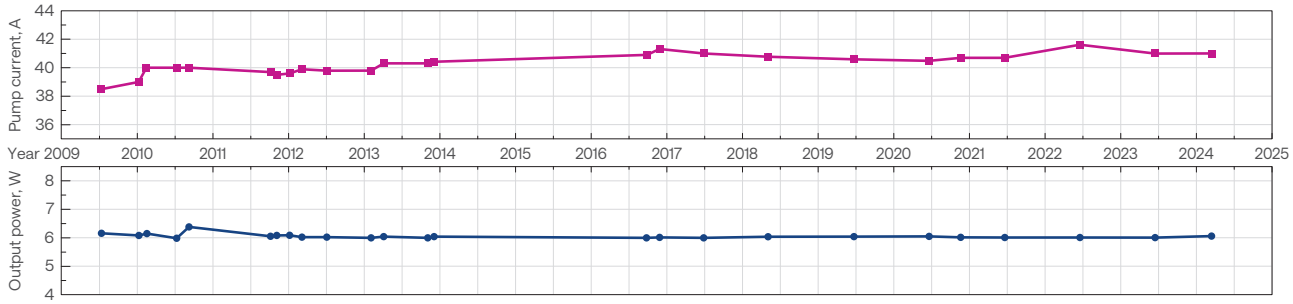


# Stability measurements

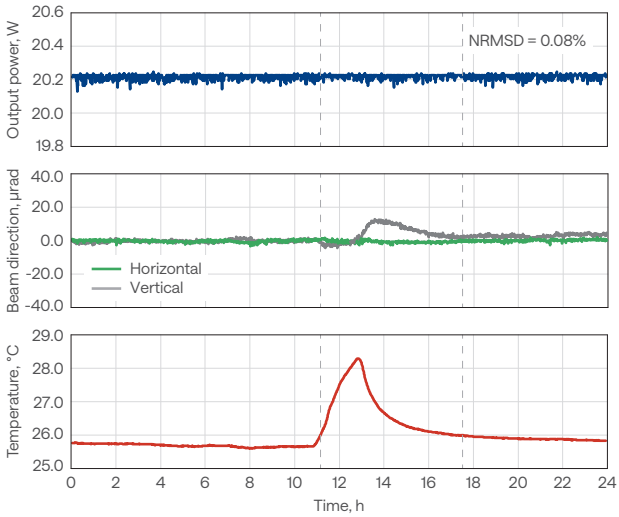
**PHAROS**
Long-term power stability



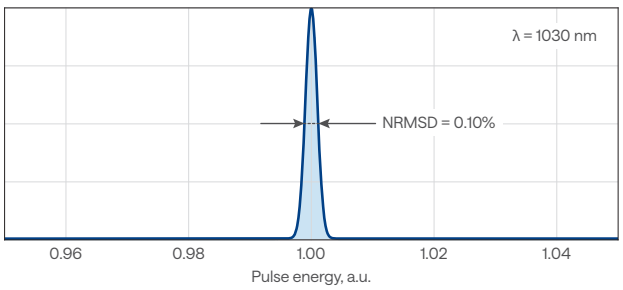

Output power of industrial-grade **PHAROS** lasers operating 24/7 and the current of the pump diodes over the years




**PHAROS** output power and beam pointing stability with power lock enabled, across varying environmental conditions



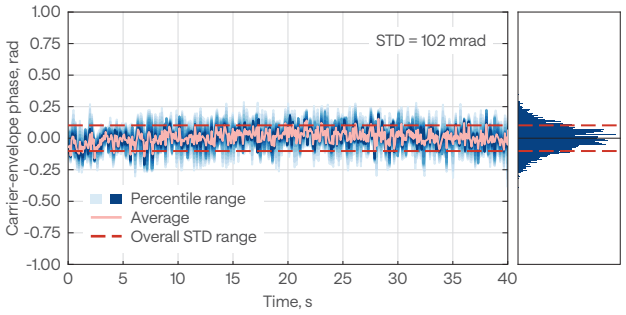

**PHAROS**
Typical pulse-to-pulse energy stability



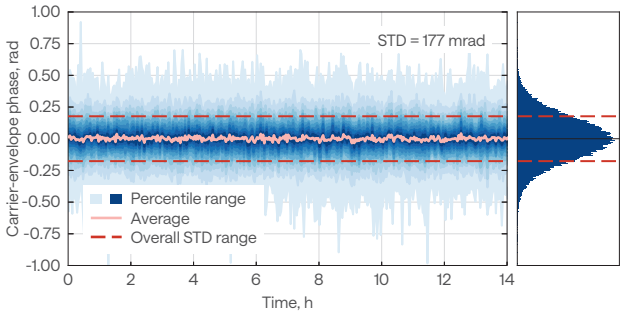
## CEP stabilization

**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 1/4$^{th}$ 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

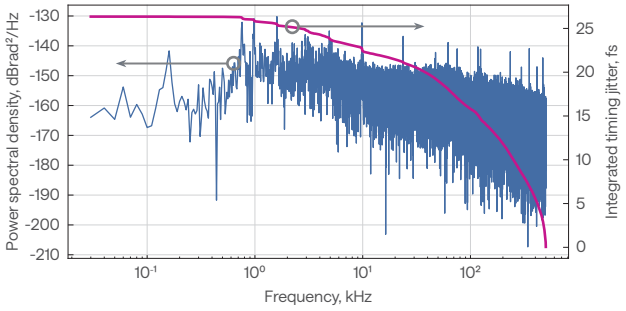



## Repetition rate locking

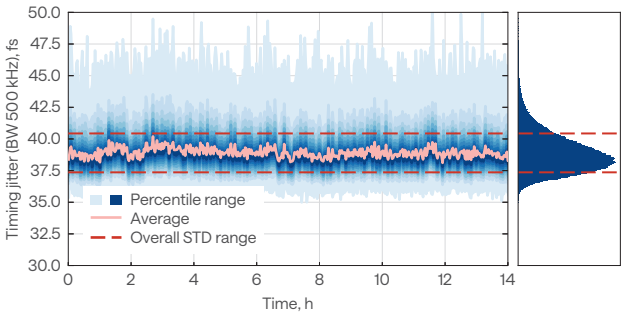
The oscillators in **PHAROS** lasers can be customized for repetition rate locking applications. Coupled with the necessary feedback electronics, the oscillator's repetition rate can be synchronized to an external RF source using the two piezo stages installed within the cavity.

The repetition rate locking system ensures an integrated timing jitter of less than 200 fs for RF reference frequencies above 500 MHz. Additionally, continuous phase shifting is available upon request.

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

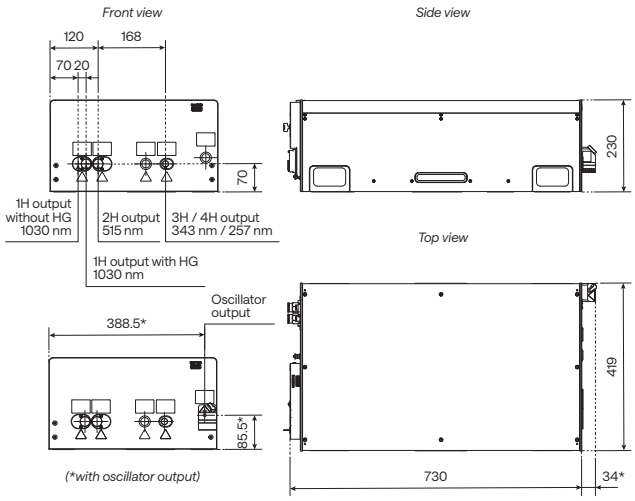



Timing jitter stability over 14 h
**PHAROS** oscillator locked to a 2.8 GHz RF source

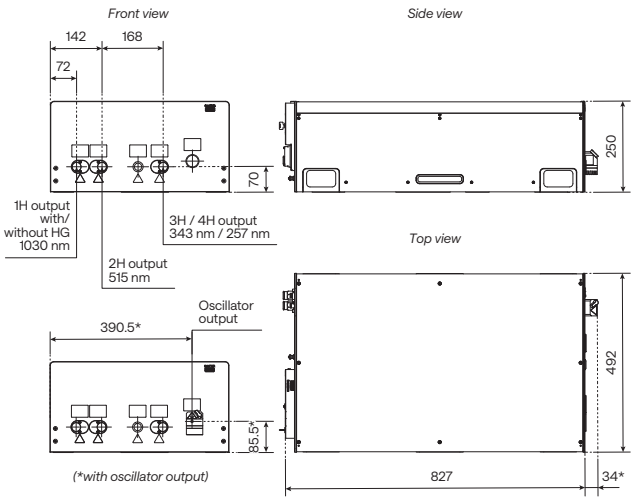



## Drawings

**PHAROS-PH2-730**
-10W or -20W-SP with a FEC or BiBurst option, or a harmonic generator




**PHAROS-PH2-827**
-10W with an -HE harmonic generator option, or -5mJ




*The drawings depend on the exact configuration. If crucial for integration, please contact sales@lightcon.com.*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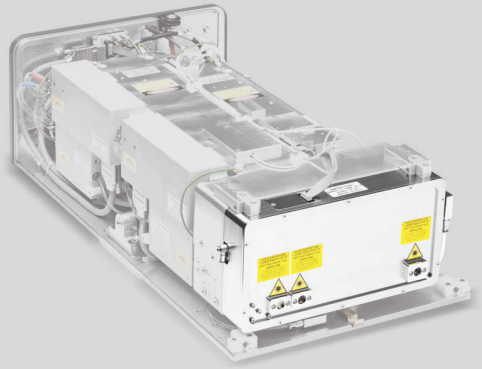
# HG | PHAROS

## Integrated Harmonic Generators

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



PHAROS with a harmonic generator

## Specifications

| Model | | 2H (-HE) | 2H-3H (-HE) | 2H-4H (-HE) | 4H-5H |
|---|---|---|---|---|---|
| Output wavelength [1] (automated selection) | | 1030 nm<br>515 nm | 1030 nm<br>515 nm<br>343 nm | 1030 nm<br>515 nm<br>257 nm | 1030 nm<br>257 nm<br>206 nm |
| Pump pulse energy [2] | | 20 – 2000 µJ | 20 – 2000 µJ | 20 – 2000 µJ | 200 – 2000 µJ |
| Pump pulse duration | | 100 – 500 fs | | | |
| Conversion efficiency | | > 50% (2H) | > 50% (2H)<br>> 25% (3H) | > 50% (2H)<br>> 10% (4H) [3] | > 10% (4H) [4]<br>> 5% (5H) [5] |
| Beam quality, $M^2$ | ≤ 400 µJ pump | <1.3 (2H) | <1.3 (2H)<br><1.4 (3H) | <1.3 (2H)<br>n/a (4H) | n/a |
| | > 400 µJ pump | <1.4 (2H) | <1.4 (2H)<br><1.5 (3H) | <1.4 (2H)<br>n/a (4H) | |

[1] *Depends on the pump laser model.*
[2] *For more pump energy options contact sales@lightcon.com*
[3] *Maximum output power: 2 W at 20 – 1000 µJ pump energy, or 1 W at 1000 – 2000 µJ pump energy.*
[4] *Maximum output power of 1 W.*
[5] *Maximum output power of 150 mW.*

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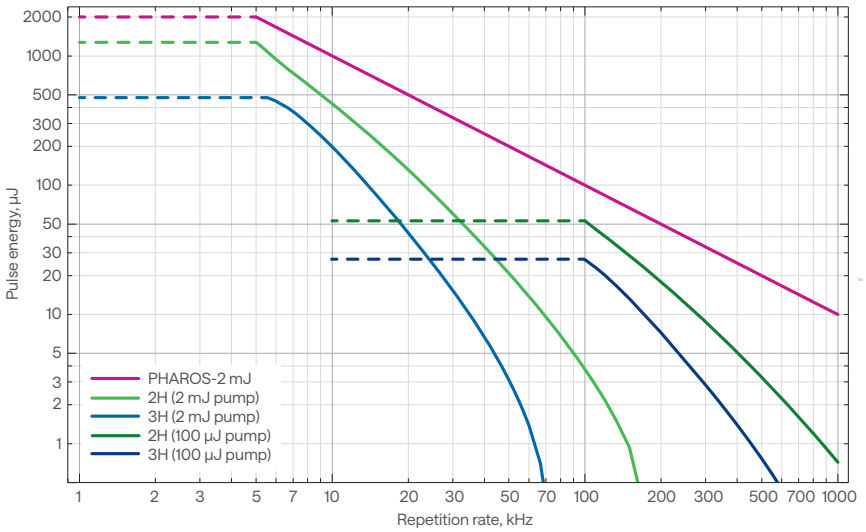
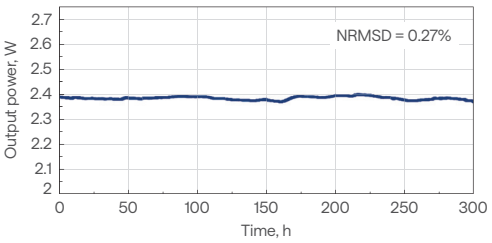
CLASS 4 LASER PRODUCT

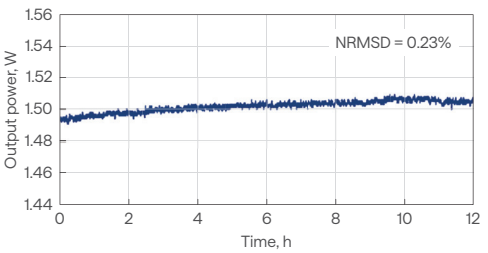
**PHAROS** with a harmonic generator
Pulse energy vs repetition rate




3H output power stability




4H output power stability



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# BiBurst

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

Water-cooled **CARBIDE** and **PHAROS** lasers feature the tunable GHz and MHz burst option with burst-in-burst capability, known as BiBurst.

In standard mode, the laser emits a single pulse at a fixed frequency. In burst mode, the output consists of pulse packets instead of single pulses. Each packet consists of a specific number of equally separated pulses. MHz-Burst contains N pulses with a nanosecond period, while GHz-Burst contains P pulses with a picosecond period. When both burst modes are combined, the equally separated pulse packets contain sub-packets of pulses, forming the burst-in-burst or BiBurst.

**CARBIDE** and **PHAROS** lasers, equipped with tunable GHz and MHz bursts and BiBurst options, bring new capabilities to high-tech manufacturing industries, such as consumer electronics, integrated photonic chip production, advanced display manufacturing, and quantum technologies.

Applications:

- Brittle material drilling and cutting
- Deep engraving
- Selective ablation
- Volume modification of transparent materials
- Hidden marking
- Surface polishing
- Functional surface structuring

## Specifications

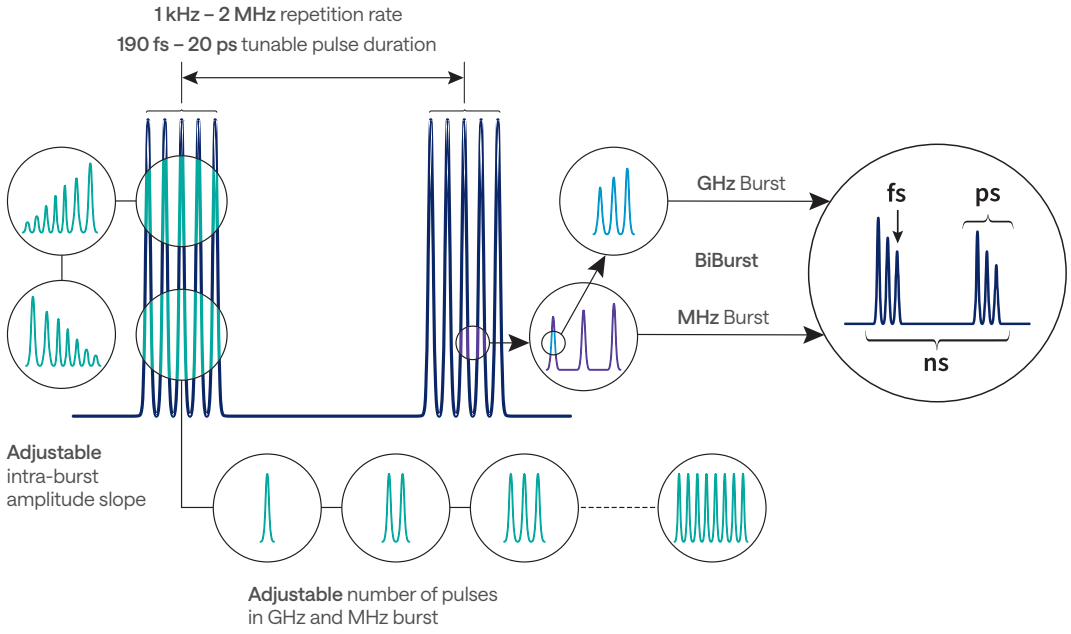
| Model | | CARBIDE-CB3 | PHAROS |
|---|---|---|---|
| GHz Burst | Intra burst pulse period [1] | 440 ± 40 ps | 200 ± 40 ps |
| | Number of pulses, P [2] | 1 – 10 (up to 400) [3] | 1 – 25 |
| MHz Burst | Intra burst pulse period | ≈ 15 ns | |
| | Number of pulses, N [2] | 1 – 10 | 1 – 9 (7 with FEC) [4] |

[1] *Custom spacing is available on request. For CARBIDE-CB3-10MHz model standard pulse period is 1500 ps.*

[2] *The maximum number of pulses in a burst depends on the laser repetition rate and energy. CARBIDE-CB3-10MHz model is limited up to 5 pulses.*

[3] *The maximum number of P pulses can be increased to 350 – 400 with optional long GHz burst mode.*

[4] *Fast energy control option. Enables formation of any pulse envelope at laser pulse repetition rate.*



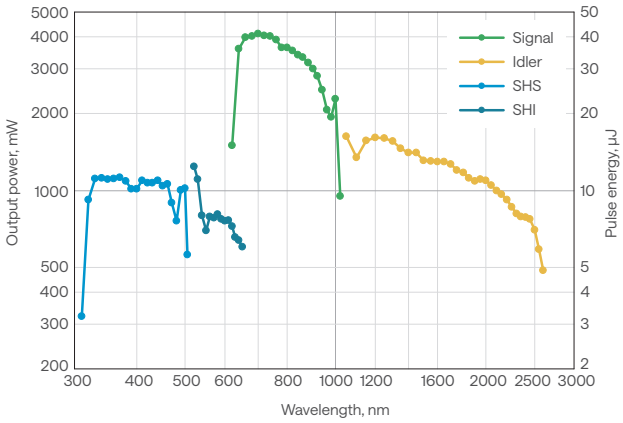
# I-OPA

## Industrial-Grade Optical Parametric Amplifier

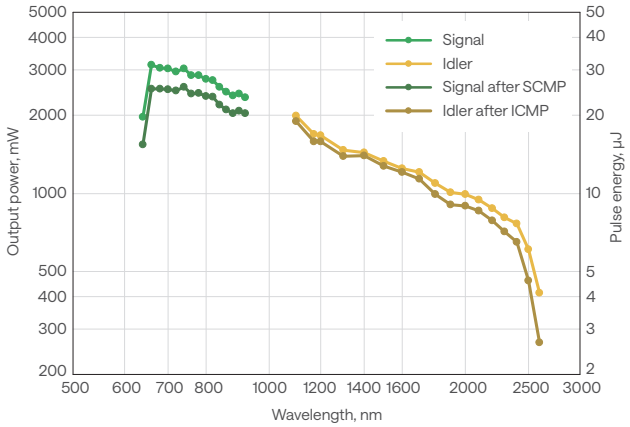
- Wavelength tunability in an industrial design
- Single-box solution
- Tunable or fixed-wavelength models
- Plug-and-play installation and robust performance
- The most compact OPA in the market


CARBIDE-CB3 with I-OPA-HP

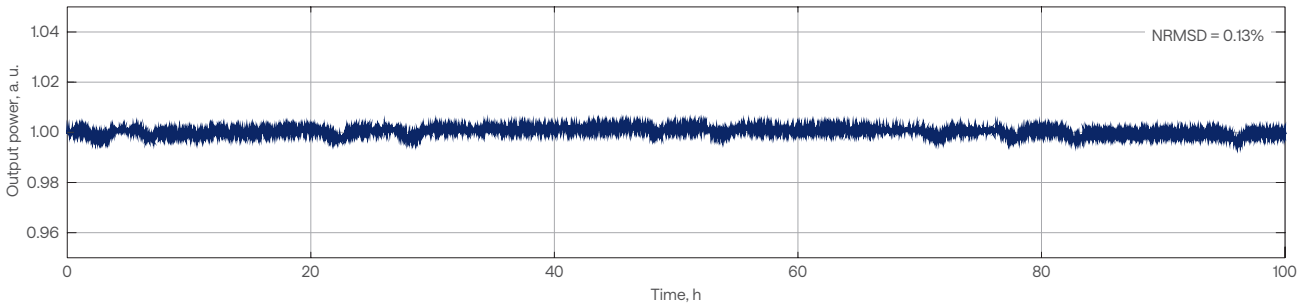
**I-OPA-HP** typical tuning curves
Pump: 40 W, 400 µJ, 100 kHz




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




**I-OPA-HP**
Typical power stability at 1300 nm



# 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)<br>1050 – 2600 nm (idler) | 650 – 920 nm (signal)<br>1200 – 2500 nm (idler) | 1350 – 2000 nm (signal)<br>2100 – 4500 nm (idler) |
| Conversion efficiency | > 7% @ 700 nm<br>(40 – 400 µJ pump; up to 1 MHz) | | > 9% @ 1550 nm<br>(40 – 400 µJ pump; up to 1 MHz) |
| | > 3.5% @ 700 nm<br>(20 – 40 µJ pump; up to 2 MHz) | | > 6% @ 1550 nm<br>(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<br>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<br>< 70 fs @ 650 – 800 nm<br>< 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]<br>525 – 640 nm (SHI) [5] | Contact<br>sales@lightcon.com | 4500 – 10 000 nm (DFG) |
| Pulse compression options [2] | n/a | SCMP (signal pulse compressor)<br>ICMP (idler pulse compressor) | n/a |

## PUMP LASER REQUIREMENTS

| | |
|---|---|
| Pump laser | CARBIDE or PHAROS |
| 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

Refer to lightcon.com

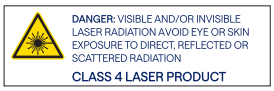
[1] *In the case of a fixed wavelength (FW), a single wavelength can be selected from the signal or idler range. The signal may have an accessible idler pair, and vice versa.*

[2] *I-OPA-F broad-bandwidth pulses are compressed externally. Typical pulse duration before compression: 120 – 250 fs, after compression: 25 – 70 fs @ 650 – 920 nm, 40 – 100 fs @ 1200 – 2000 nm.*

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

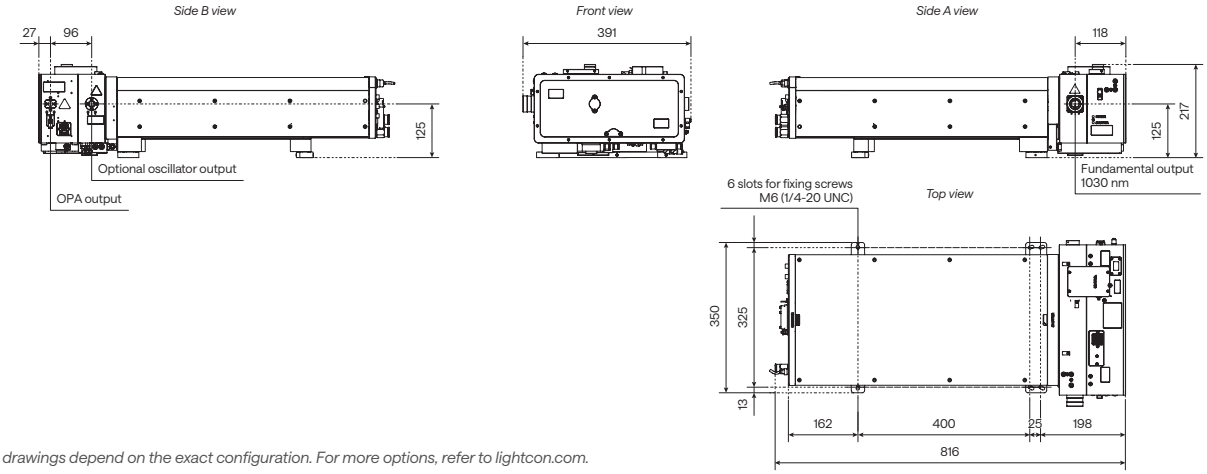
[4] *Expressed as normalized root mean squared deviation (NRMSD).*

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




# Drawings

CARBIDE-CB3 with I-OPA-HP




*The drawings depend on the exact configuration. For more options, refer to lightcon.com.*





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