PHAROS

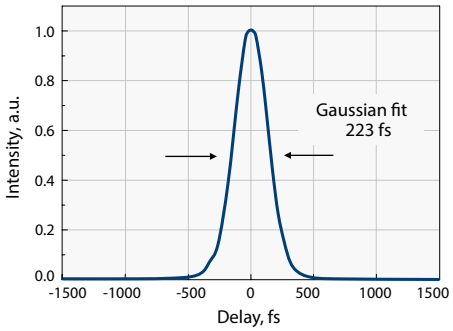
GD000001 Light Conversion Pharos Datasheets

High Power and Energy Femtosecond Lasers

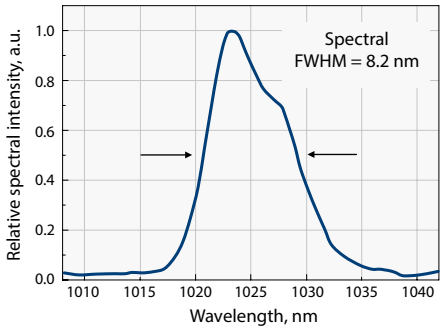
FEATURES

- 190 fs – 20 ps tunable pulse duration
- 2 mJ maximum pulse energy
- 20 W output power
- 1 kHz – 1 MHz tunable base repetition rate
- Pulse picker for pulse-on-demand operation
- Rugged industrial grade mechanical design
- Automated harmonics generators (515 nm, 343 nm, 257 nm, 206 nm)
- Optional CEP stabilization
- Possibility to lock oscillator to external clock

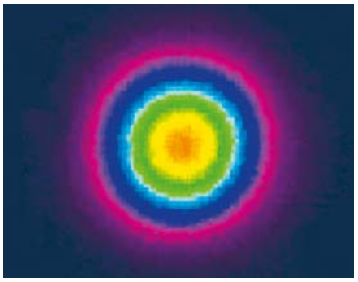
PHAROS is a single-unit integrated femtosecond laser system combining millijoule pulse energies and high average powers. PHAROS features a mechanical and optical design optimized for industrial applications such as precise material processing. Compact size, integrated thermal stabilization system and sealed design allow PHAROS integration into machining workstations. The use of solid state laser diodes for pumping of Yb medium significantly reduces maintenance cost and provides long laser lifetime. Most of the PHAROS output parameters can be easily set via PC in seconds. Tunability of laser output parameters allows PHAROS system to cover applications normally requiring different classes of lasers. Tunable parameters include: pulse duration (190 fs – 20 ps), repetition rate (single pulse to 1 MHz), pulse energy (up to 2 mJ) and average power (up to 20 W). Its deliverable power is sufficient for most of material processing applications at high machining speeds. The built-in pulse picker allows convenient control of the laser output in pulse-on-demand mode. PHAROS compact and robust optomechanical design features stable laser operation across varying environments. PHAROS is equipped with an extensive software package which ensures smooth hands-free operation.



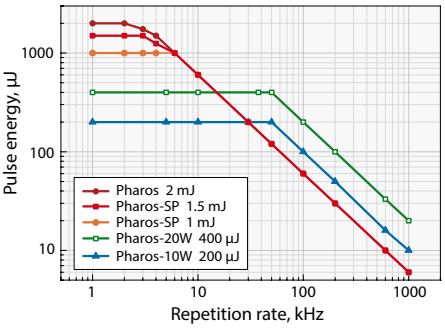
Pulse duration of PHAROS



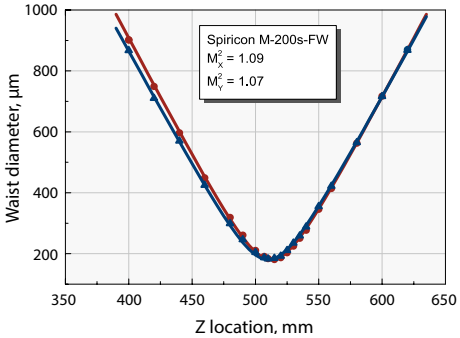
Spectrum of PHAROS



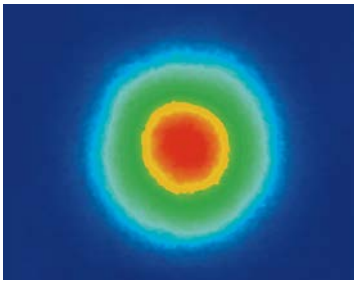
Typical PHAROS far field beam profile at 200 kHz



Pulse energy vs base repetition rate



Typical PHAROS M^2 measurement data



Typical PHAROS near field beam profile at 200 kHz

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SPECIFICATIONS

Product name	PH1-10	PH1-15	PH1-20	PH1-SP-1mJ	PH1-SP-1.5mJ	PH1-SP-10W	PH1-2mJ
Max. average power	10 W	15 W	20 W	6 W		10 W	6 W
Pulse duration (assuming Gaussian pulse shape)	< 290 fs			< 190 fs			< 300 fs
Pulse duration range	290 fs – 10 ps (20 ps on request)			190 fs – 10 ps (20 ps on request)			300 fs – 10 ps
Max. pulse energy	> 0.2 mJ or > 0.4 mJ			> 1 mJ	> 1.5 mJ	> 1 mJ	> 2 mJ
Beam quality	TEM_{00} ; M^2 < 1.2			TEM_{00} ; M^2 < 1.3			
Base repetition rate	1 kHz – 1 MHz [1]						
Pulse selection	Single-Shot, Pulse-on-Demand, any base repetition rate division						
Centre wavelength	1028 nm ± 5 nm						
Output pulse-to-pulse stability	< 0.5 % rms over 24 hours [2]						
Power stability	< 0.5 % rms over 100 h						
Pre-pulse contrast	< 1 : 1000						
Post-pulse contrast	< 1 : 200						
Polarization	Linear, horizontal						
Beam pointing stability	< 20 µrad/°C						
Oscillator output	Optional, please contact sales@lightcon.com for specifications						
Burst mode							

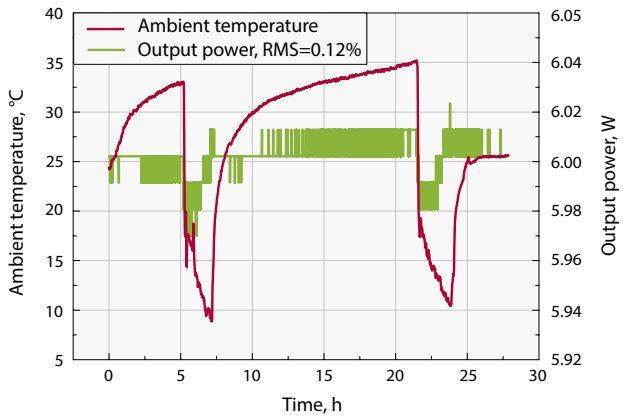
PHYSICAL DIMENSIONS

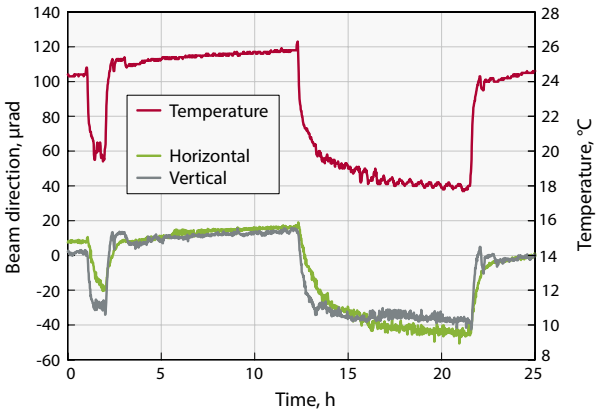
Laser head	670 (L) × 360 (W) × 212 (H) mm [3]
Rack for power supply and chiller	642 (L) × 553 (W) × 673 (H) mm

UTILITY REQUIREMENTS

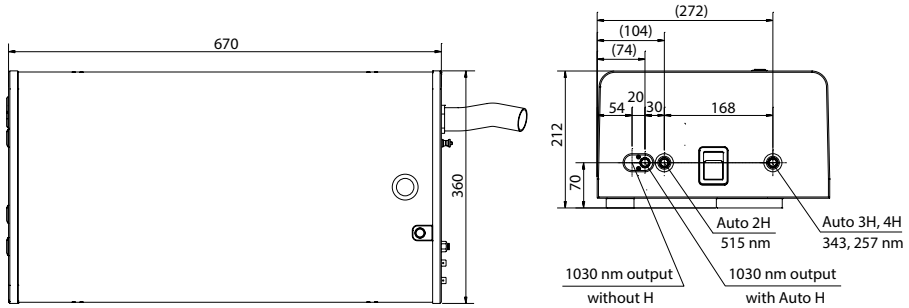
Electric	110 V AC, 50 – 60 Hz, 20 A or 220 V AC, 50 – 60 Hz, 10 A
Operating temperature	15 – 30 °C (air conditioning recommended)
Relative humidity	< 80 % (non condensing)

[1] *Some particular repetition rates are software denied due to system design.*
[2] *Under stable environmental conditions.*
[3] *Dimensions might increase for non-standard laser specifications*

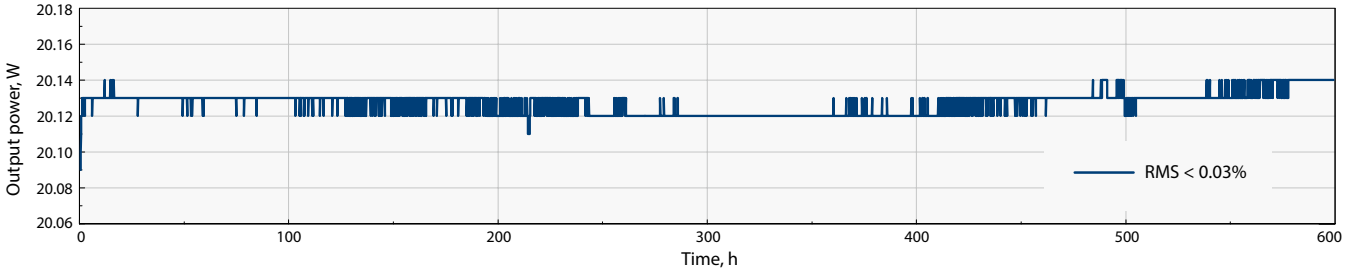




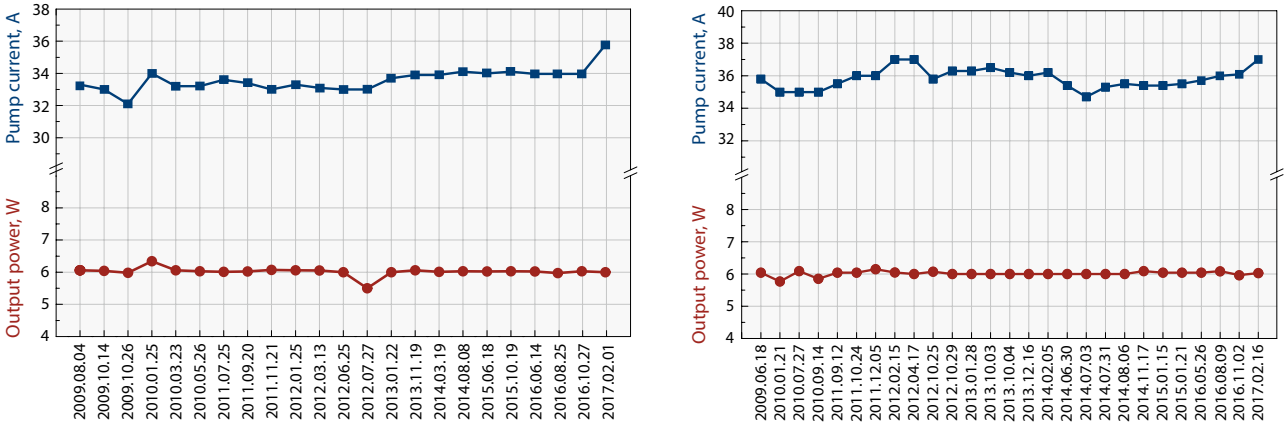
PHAROS output power with power lock enabled under unstable environment



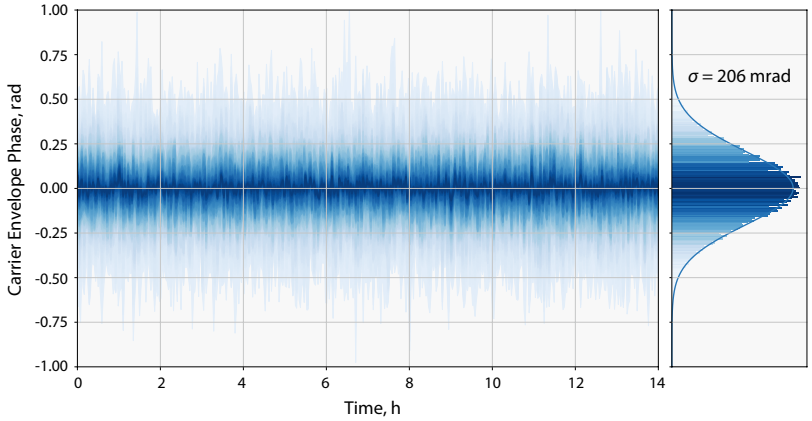
PHAROS laser outline drawing



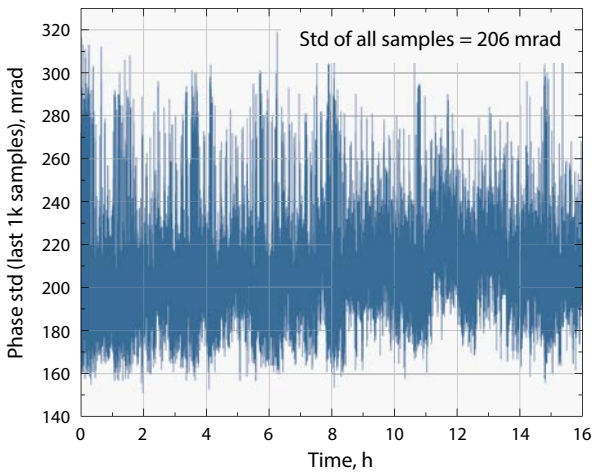
PHAROS long term stability graph



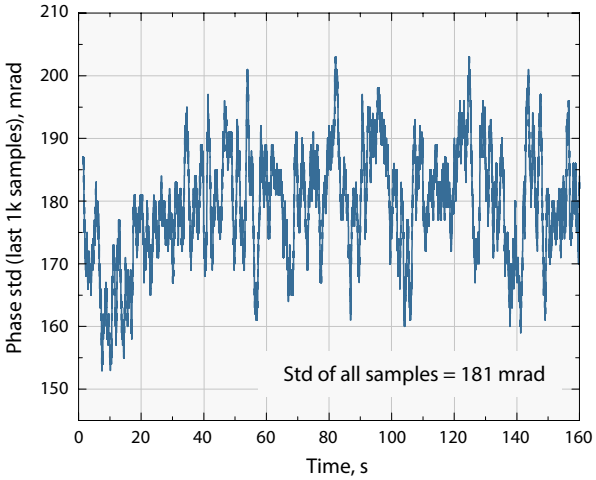
Output power of industrial PHAROS lasers operating 24/7 and current of pump diodes during the years



Carrier envelope phase (CEP) over the long period with active phase stabilization system



CEP stability over a long time scale



CEP stability over a short time scale

Pharos CEP stability when laser is isolated from all noticeable noise sources – vibrations, acoustics, air circulation and electrical noise. System can achieve < 300 mrad std of CEP stability over a long time scale (> 8 hours) and < 200 mrad over a short time scale (< 5 min)

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LIGHT CONVERSION

PHAROS

Automated Harmonics Generators

FEATURES

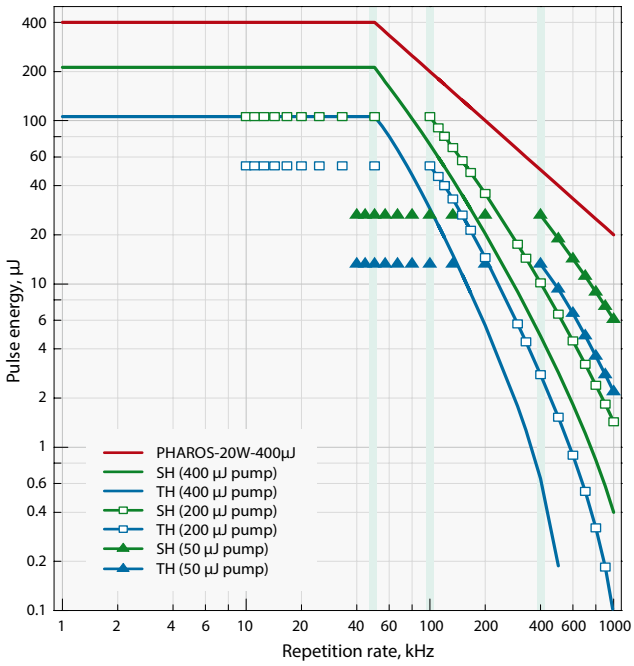
- 515 nm, 343 nm, 257 nm and 206 nm
- Output selection by software
- Mounts directly on a laser head and integrated into the system
- Rugged industrial grade mechanical design

PHAROS laser can be equipped with automated harmonics modules. Selection of fundamental (1030 nm), second (515 nm), third (343 nm), fourth (257 nm) or fifth (206 nm) harmonic output is available through software control. Harmonics generators are designed to be used in industrial applications where a single output wavelength is desired. Modules are mounted directly on the output of the laser and integrated into the system.

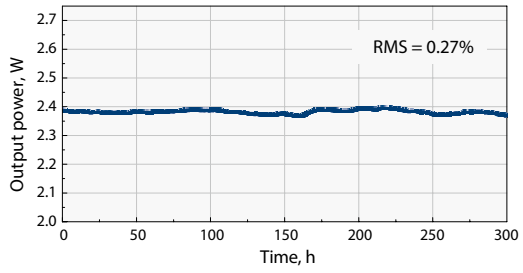
SPECIFICATIONS

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

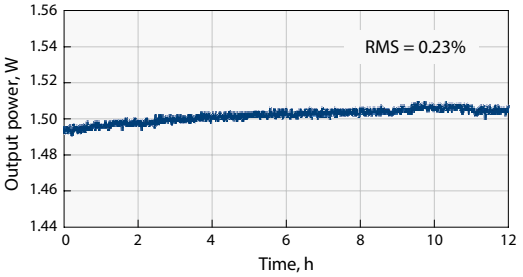
[1] *Max 1 W output.* [2] *Max 0.15 W output.*



PHAROS harmonics energy vs pulse repetition rate



3H output stability



4H output stability

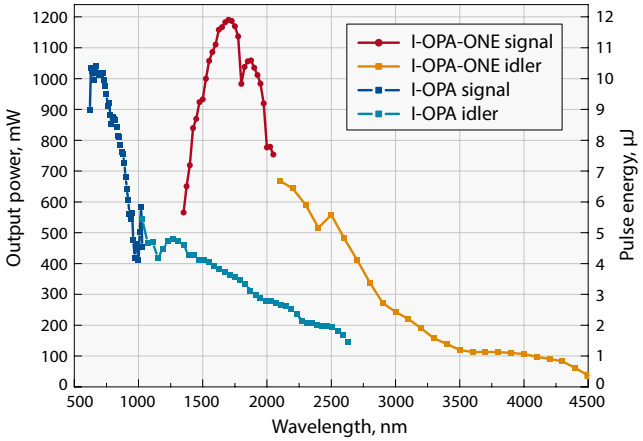
PHAROS

Industrial grade Optical Parametric Amplifier

FEATURES

- Based on experience with ORPHEUS line
- Manually tunable wavelength
- Industrial grade design provides excellent long-term stability
- Very small footprint
- Bandwidth limited or short-pulse configurations available
- CEP option available

I-OPA is the first industrial grade optical parametric amplifier which features long-term stable output with a reliable hands-free operation. Manually tunable output wavelength extends application possibilities of a single laser source instead of requiring multiple lasers based on different technologies.
In comparison to standard ORPHEUS line devices, the I-OPA lacks only a computer controlled wavelength selection. On the other hand, in-laser mounted design provides mechanical stability and eliminates the effects of air-turbulence ensuring stable long-term performance and minimizing energy fluctuations.



I-OPA module energy conversion curves.
Pump: PHAROS-10W, 100 µJ, 100 kHz

PHAROS I-OPA MODEL COMPARISON TABLE

Product name	I-OPA	I-OPA-F	I-OPA-ONE
Based on ORPHEUS model	ORPHEUS	ORPHEUS-F	ORPHEUS-ONE
Pump pulse energy	10 – 500 µJ	10 – 500 µJ	20 – 1000 µJ
Pulse repetition rate	Up to 1 MHz		
Tuning range of signal	630 – 1030 nm	650 – 900 nm	1350 – 2060 nm
Tuning range of idler	1030 – 2600 nm	1200 – 2500 nm	2060 – 4500 nm
Conversion efficiency at peak, signal+idler combined	> 12 % when pump energy 20 – 500 µJ > 6 % when pump energy 10 – 20 µJ	> 10 %	> 14 % when pump energy 30 – 1000 µJ > 10 % when pump energy 20 – 30 µJ
Pulse bandwidth [1]	80 – 150 cm^{-1} @ 700 – 960 nm when pumped by Pharos 100 – 220 cm^{-1} @700 – 960 nm when pumped by Pharos-SP	200 – 750 cm^{-1} @ 650 – 900 nm 150 – 500 cm^{-1} @ 1200 – 2000 nm	60 – 150 cm^{-1} @ 1450 – 2000 nm
Pulse duration [2]	130 – 290 fs when pumped by Pharos 120 – 190 fs when pumped by Pharos-SP	< 55 f @ 800 – 900 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	200 – 300 fs
Applications	Micro-machining Microscopy Spectroscopy	Nonlinear microscopy Ultrafast spectroscopy	Micro-machining Mid-IR generation

[1] *I-OPA-F outputs broad bandwidth pulses which are compressed externally.*
[2] *Output pulse duration depends on wavelength and pump laser pulse duration.*

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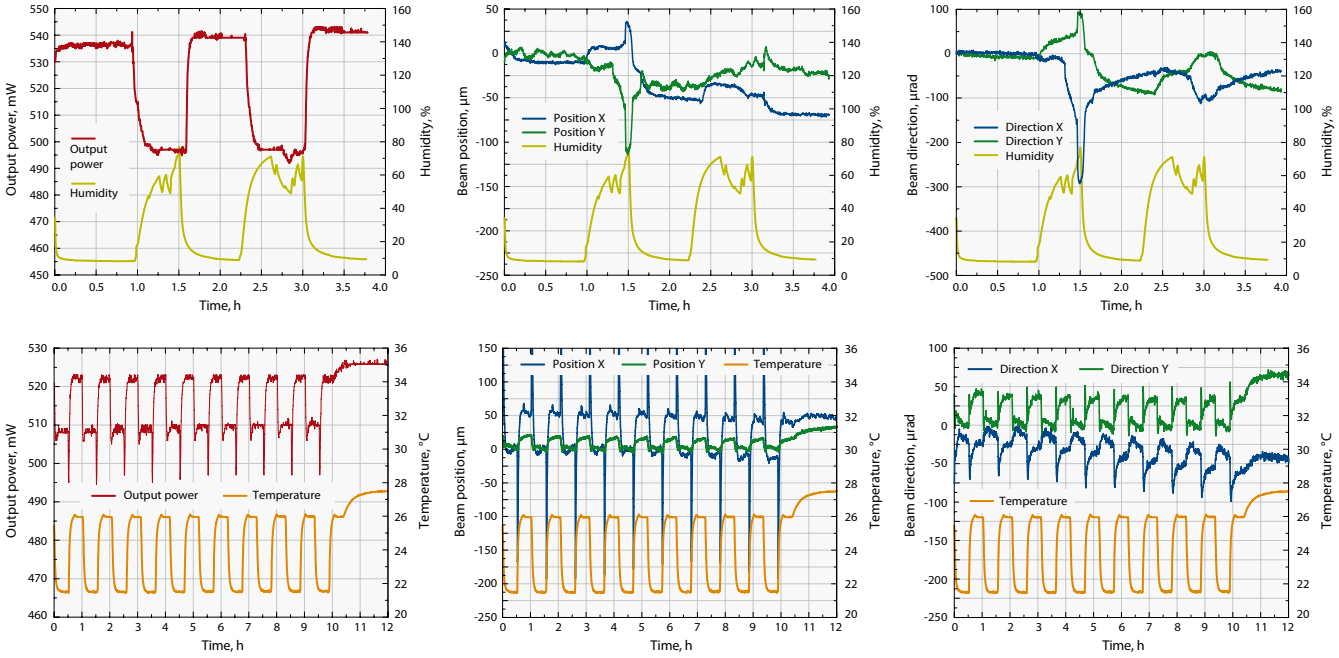
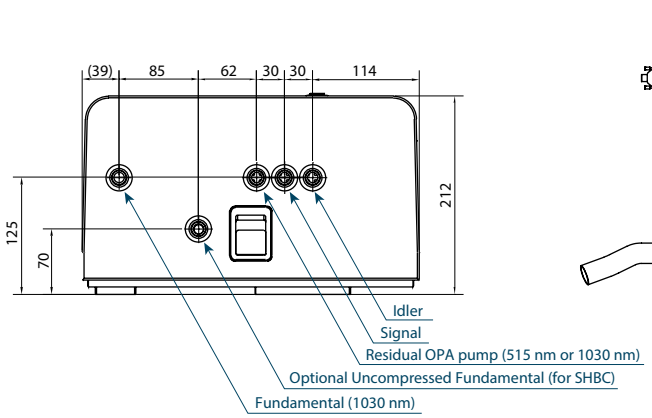
COMPARISON WITH OTHER FEMTOSECOND AND PICOSECOND LASERS

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

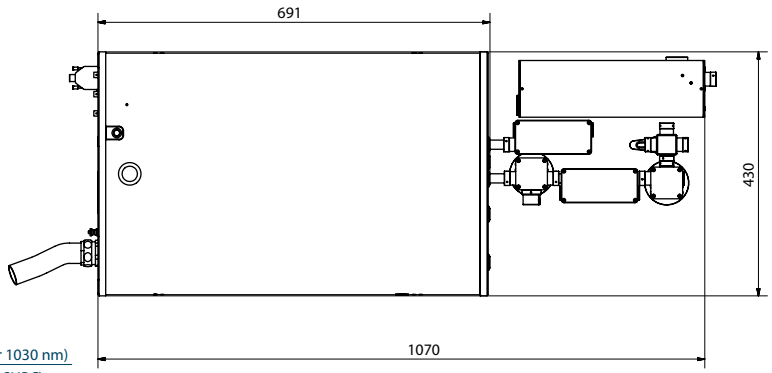
Note that the pulse energy scales linearly in a broad range of pump parameters. For example, a PHAROS-20W laser at 50 kHz (400 µJ energy) will increase the output power twice, and the pulse energy – 4 times compared to the reference table above. The pulse duration at the output is <300 fs in all cases.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



I-OPA beam pointing and output power measurements under harsh environment conditions (humidity and temperature cycling)



Pharos with I-OPA output ports



PHAROS with I-OPA-F and compressors for signal and ilder