ORPHEUS

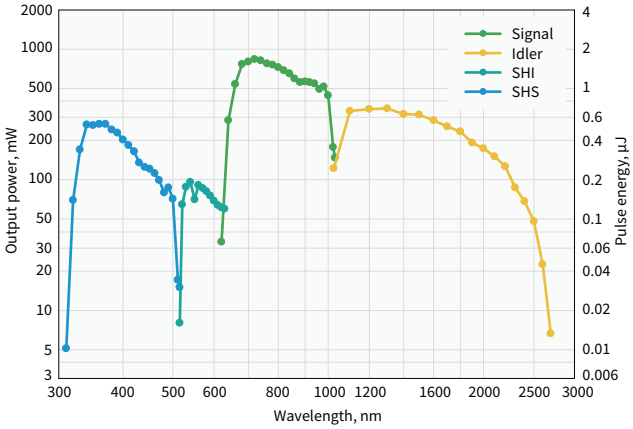
Collinear Optical Parametric Amplifier

FEATURES

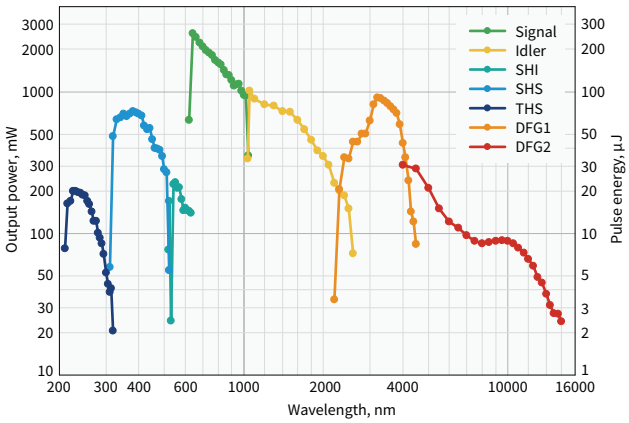
- 190 – 16000 nm tuning range
- Single-shot – 2 MHz repetition rate
- Up to 80 W pump power
- Up to 2 mJ pump pulse energy
- Completely automated

ORPHEUS is a collinear optical parametric amplifier (OPA). Coupled with a PHAROS or CARBIDE femtosecond laser, ORPHEUS emits femtosecond pulses tunable from ultraviolet (UV) to mid-infrared (MIR) at a repetition rate of up to 2 MHz. Thus, it is an invaluable tool for ultrafast spectroscopy, nonlinear microscopy, and microstructuring applications.

The ORPHEUS collinear OPA comes in three different configurations to perfectly match the customer needs. The basic ORPHEUS configuration is a cost-effective choice providing a wide and gapless tuning range from 630 to 2600 nm, which is extendable down to 210 nm with an external harmonic generator. If higher pump power and a higher-level of automation are desired, the ORPHEUS-HP configuration is your choice. It offers complete automation and integrates all of the wavelength extension options into a single thermally-stabilized housing. Its wavelength tuning is completely hands-free and uses automated wavelength separation to ensure the same position and direction for the 190 – 2600 nm output. The spectral range is extendable up to 16 µm; thus, covering the entire spectrum from UV to MIR. Similar to ORPHEUS-HP, the ORPHEUS-HE configuration brings the aforementioned automation but also accepts high pump pulse energy.



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



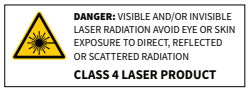
Typical tuning curves of **ORPHEUS-HE**.
Pump: 20 W, 2 mJ, 10 kHz

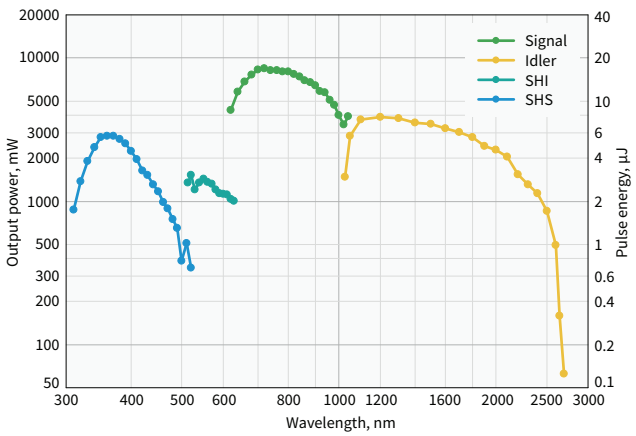
For custom tuning curves visit *http://toolbox.lightcon.com/tools/tuningcurves/*

SPECIFICATIONS

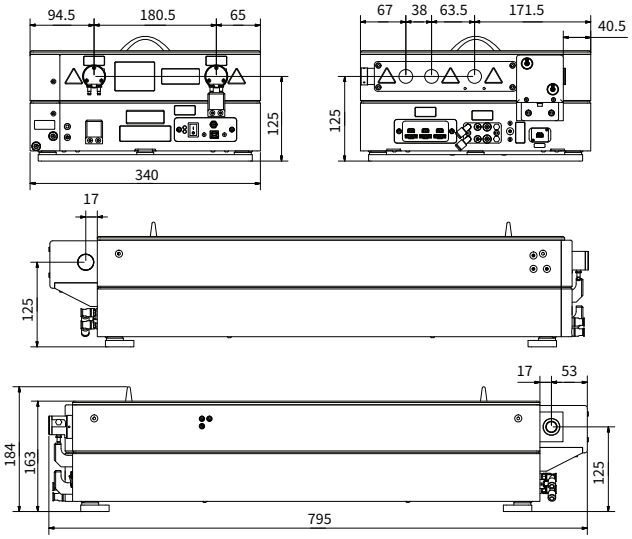
Model	ORPHEUS		ORPHEUS-HP		ORPHEUS-HE
MAIN OUTPUT (630 – 2600 nm)					
Tuning range	630 –1030 nm (Signal) 1030 – 2600 nm (Idler)				
Maximum pump power	8 W		80 W		
Pump pulse energy	8 – 20 µJ	20 – 400 µJ	8 – 20 µJ	20 – 400 µJ	400 – 2000 µJ [1]
Conversion efficiency at peak	> 6% (Signal and Idler combined)	> 12% (Signal and Idler combined)	> 4.5% (Signal) > 2% (Idler)	> 9% (Signal) > 4% (Idler)	
Integrated 2H (515 nm) generation efficiency	> 35% [2]		not specified		
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				
WAVELENGTH EXTENSIONS (190 – 16000 nm)					
Pump pulse energy	8 – 20 µJ	20 – 400 µJ	8 – 20 µJ	20 – 400 µJ	400 – 2000 µJ [1]
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 (DUV)	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] Pump energy of up to 5 mJ available; contact sales@lightcon.com for details.
[2] At designated output port B; not simultaneous to OPA output.
[3] Expressed as NRMSD (normalized root mean squared deviation).
[4] Maximum output power of 400 mW.
[5] For pump power of < 10 W. Maximum output power of 40 mW @ 200 nm.





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



ORPHEUS-HP drawings

ORPHEUS | F

Broad-Bandwidth Hybrid Optical Parametric Amplifier

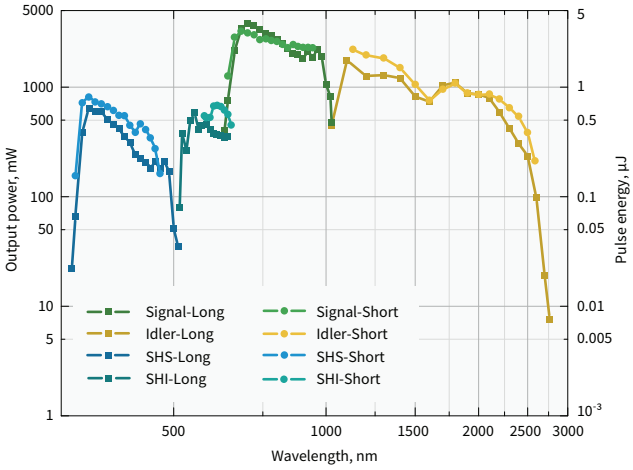
FEATURES

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

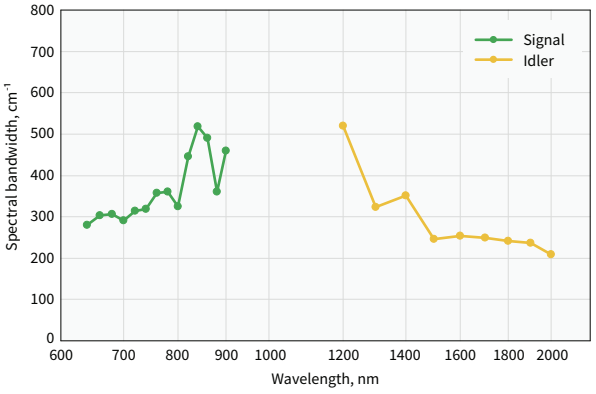
ORPHEUS-F is a hybrid optical parametric amplifier (OPA), combining the short pulse duration produced by a non-collinear OPA (NOPA) and the wide tuning range offered by a collinear OPA.

The Signal pulses of ORPHEUS-F are tunable in a 650 – 900 nm range and can be compressed with a simple prism-based compressor down to 25 – 70 fs pulse duration. The Idler pulses are tunable in a 1200 – 2500 nm range and reach pulse duration of 40 – 100 fs. In addition, a long-pulse mode is available for accessing the 900 – 1200 nm tuning range; thus, enabling a gap-free tunability.

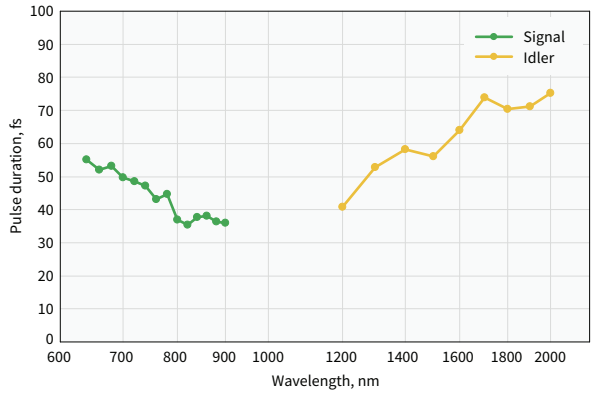
ORPHEUS-F provides significantly shorter pulses compared to the standard ORPHEUS model and a wider tuning range compared to the non-collinear ORPHEUS-N. Thus, for many scientific applications, ORPHEUS-F is the optimal choice.



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



Typical spectral bandwidth of ORPHEUS-F



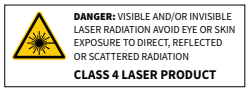
Pulse duration after compression of ORPHEUS-F

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

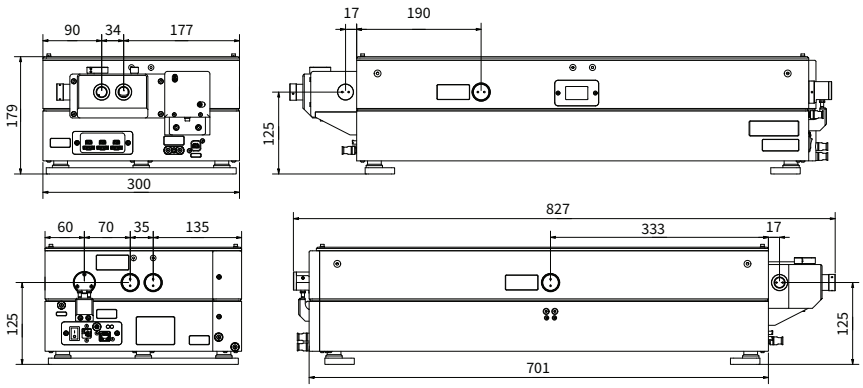
SPECIFICATIONS

Model	ORPHEUS-F	
MAIN OUTPUT (650 – 900 nm and 1200 – 2500 nm)		
Mode of operation	Short pulse mode [1]	Long pulse mode
Tuning range	650 – 900 nm (Signal) 1200 – 2500 nm (Idler)	650 – 1010 nm (Signal) 1050 – 2500 nm (Idler)
Maximum pump power	80 W	
Pump pulse energy	10 – 500 µJ	
Conversion efficiency at peak [2]	> 10% (Signal and Idler combined)	
Integrated 2H (515 nm) generation efficiency [3]	> 35%	
Pulse duration before compression [1]	< 290 fs	
Spectral bandwidth	200 – 750 cm^{-1} @ 650 – 900 nm	75 – 220 cm^{-1} @ 650 – 900 nm
Pulse duration after compressor [1]	< 55 fs @ 800 – 900 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	n/a
Compressor transmission	> 65% @ 650 – 900 nm > 80% @ 1200 – 2000 nm	
Long-term power stability, 8h [4]	< 2% @ 800 nm	
Pulse-to-pulse energy stability, 1 min [4]	< 2% @ 800 nm	
WAVELENGTH EXTENSION OPTIONS (325 – 15000 nm) [5]		
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%
2500 – 15000 nm	See ORPHEUS-MIR *(page 34)*	

[1] *In short pulse mode, broadband 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.*
[2] *Specified as percentage of pump power.*
[3] *At designated output port; not simultaneous to OPA output.*
[4] *Expressed as NRMSD (normalized root mean squared deviation).*
[5] *For > 15 µJ pump pulse energy.*



DRAWINGS



ORPHEUS-F drawings

ORPHEUS | MIR

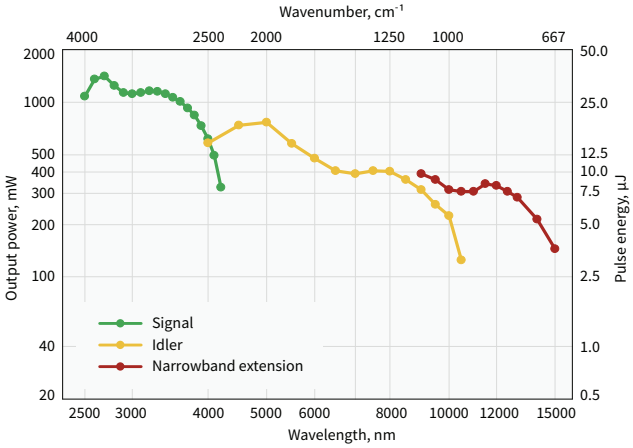
Broad-Bandwidth Mid-Infrared Optical Parametric Amplifier

FEATURES

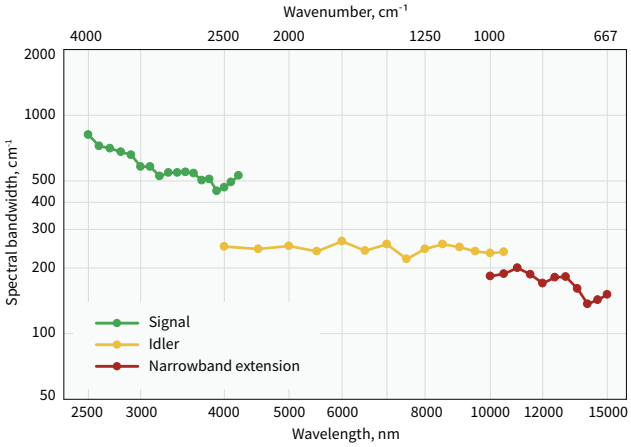
- Up to 800 cm^{-1} spectral bandwidth
- 2500 – 15 000 nm tuning range
- < 100 fs pulse duration
- Up to 400 kHz repetition rate
- Up to 80 W, 2 mJ pump
- Short-pulse high-energy output at 2000 nm
- Optimization for bandwidth
- CEP-stable option

ORPHEUS-MIR is an optical parametric amplifier (OPA) optimized for the efficient generation of broad-bandwidth MIR pulses. The laser system provides broadband pulses in the tuning range of 2.5 – 10 µm and reaches up to 15 µm with a 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 femtosecond pump lasers.

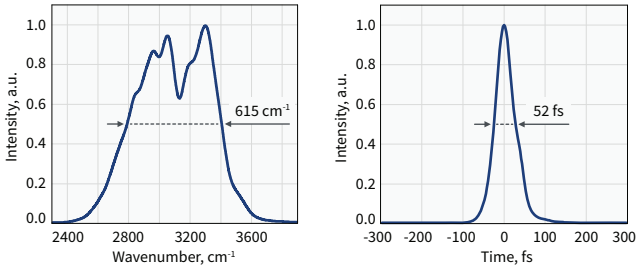
ORPHEUS-MIR serves as an excellent high-repetition-rate source for infrared spectroscopy such as broadband vibrational sum-frequency generation (SFG) spectroscopy. Combined with a narrow-bandwidth output of SHBC, it forms a compact laser system for SFG measurements, covering most of the MIR spectrum while also providing high spectral resolution. Furthermore, its high output stability is the key to fast and high-quality SFG imaging.



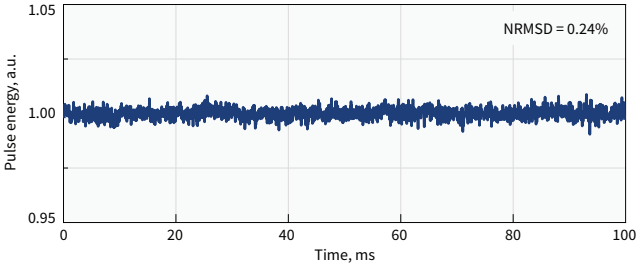
Typical tuning curves of **ORPHEUS-MIR**.
Pump: 80 W, 2 mJ, 40 kHz



Typical spectral bandwidth of **ORPHEUS-MIR**



Typical output spectrum (left) and pulse duration (right).
Measured at ≈ 3000 nm

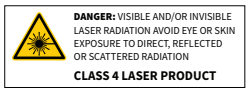


Pulse-to-pulse energy stability of **ORPHEUS-MIR**.
Measured at ≈ 3000 nm

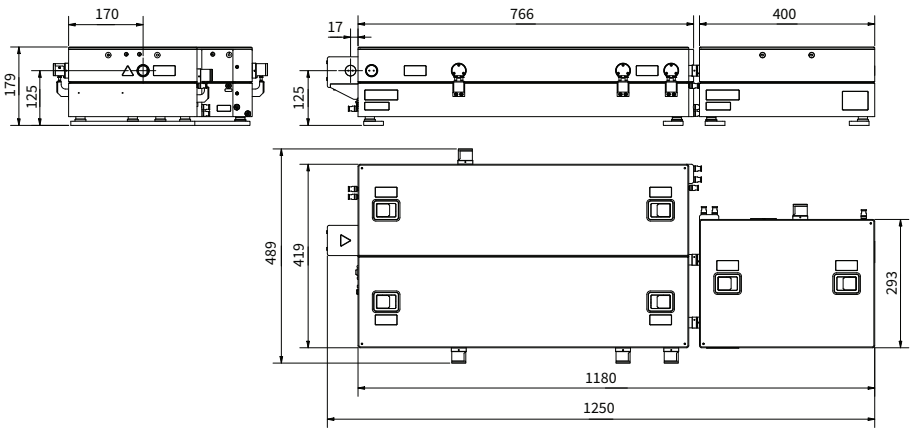
SPECIFICATIONS

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 [3]	> 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 [4]	< 2% @ 5000 nm	
Pulse-to-pulse energy stability, 1 min [4]	< 2% @ 5000 nm	
AUXILIARY OUTPUT 1 (2000 nm)		
Output wavelength [5]	2000 ± 100 nm	
Pulse duration	< 50 fs	
Conversion efficiency [2]	> 8%	
Spectral bandwidth	> 350 cm^{-1}	
AUXILIARY OUTPUT 2 (1350 – 2000 nm)		
Tuning range [6]	1350 – 2000 nm	
Pulse duration	< 300 fs	
Conversion efficiency [2]	Contact sales@lightcon.com	
Spectral bandwidth	60 – 150 cm^{-1}	
WAVELENGTH EXTENSION (10000 – 15000 nm)		
Tuning range	10000 – 15000 nm	
Pulse duration	< 300 fs	
Conversion efficiency [2]	> 0.2% @ 12 000 nm	
Spectral bandwidth	100 – 150 cm^{-1}	

[1] Optional mode of operation. Optimized for maximum spectral bandwidth at expense of conversion efficiency.
[2] Specified as a percentage of pump power.
[3] FWHM (full width at half maximum).
[4] Expressed as NRMSD (normalized root mean squared deviation).
[5] Not tunable, optimized for best overall performance. Not simultaneous to OPA output.
[6] Simultaneous to OPA output. Available on request.



DRAWINGS



ORPHEUS-MIR drawings

ORPHEUS | N

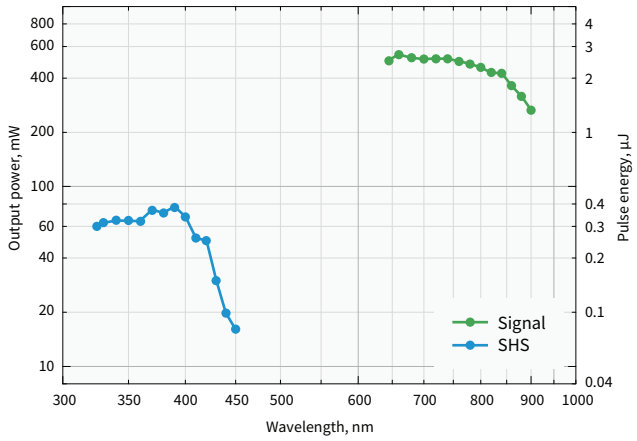
Non-Collinear Optical Parametric Amplifier

FEATURES

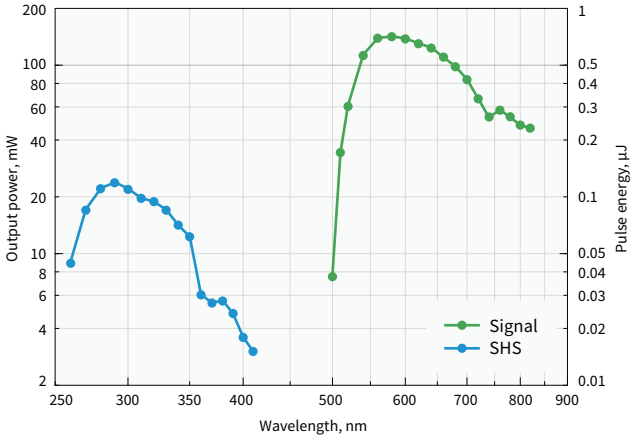
- < 30 fs pulse duration
- Integrated pulse compressor
- Adjustable spectral bandwidth and pulse duration
- Wavelength feedback with internal spectrometer

ORPHEUS-N is a non-collinear optical parametric amplifier (NOPA). Depending on the model, ORPHEUS-N has an integrated 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 < 30 fs pulses in the 700 – 850 nm range. ORPHEUS-N with a third harmonic pump (ORPHEUS-N-3H) delivers < 30 fs pulses in the 530 – 670 nm range. An optional second harmonic generator is available, extending the tuning range down to ultraviolet (UV) spectral range.

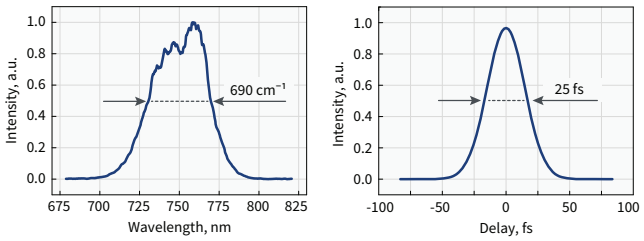
Featuring a built-in prism-based pulse compressor, ORPHEUS-N is an invaluable instrument for ultrafast spectroscopy and nonlinear microscopy. A single PHAROS or CARBIDE femtosecond laser can pump multiple NOPAs providing pump and/or probe channels with independent wavelength tuning for your state-of-the-art experiments.



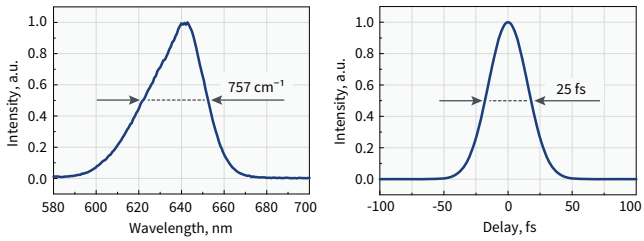
Typical tuning curves of **ORPHEUS-N-2H**
Pump: 6 W, 30 µJ, 200 kHz



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



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



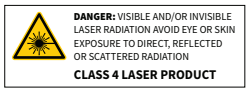
Typical output of **ORPHEUS-N-3H**

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

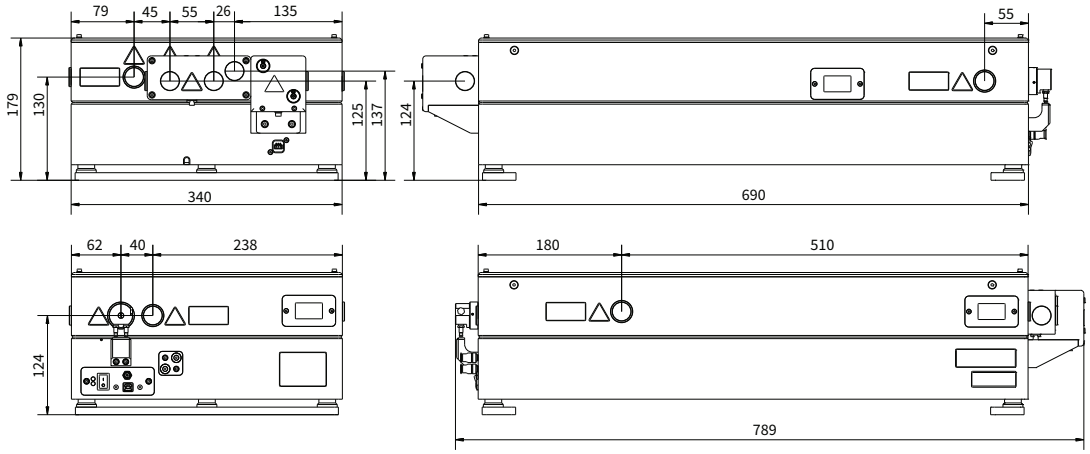
SPECIFICATIONS

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

[1] *Not simultaneous to NOPA output.*
[2] *Expressed as NRMSD (normalized root mean squared deviation).*



DRAWINGS



ORPHEUS-N drawings

ORPHEUS | ONE

Mid-Infrared Collinear Optical Parametric Amplifier

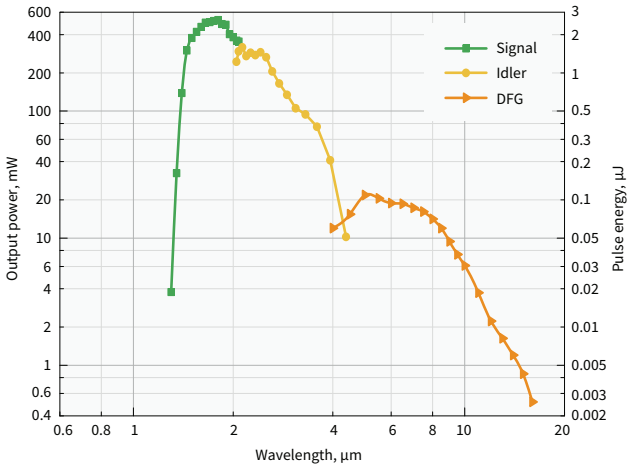
FEATURES

- 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

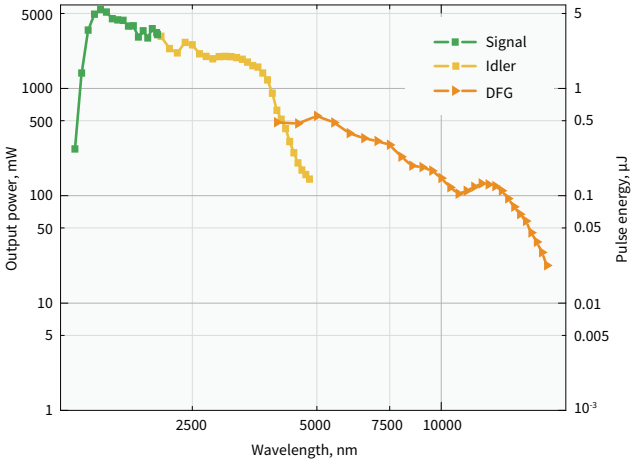
ORPHEUS-ONE is an optical parametric amplifier (OPA) designed for the mid-infrared (MIR) spectral range from 1350 to 16000 nm. Compared to ORPHEUS-HP, it has fewer wavelength extension options but provides higher pump laser conversion efficiency into MIR.

Three models of ORPHEUS-ONE offer the same tuning range, are reliable and easy to use, but vary based on the design automation and pump parameters. The basic ORPHEUS-ONE model is a cost-effective choice but is limited to 8 W pump power. The ORPHEUS-ONE-HP enables up to 80 W pump power, while the ORPHEUS-ONE-HE accepts the same pump power but also pulse energy of up to 2 mJ.

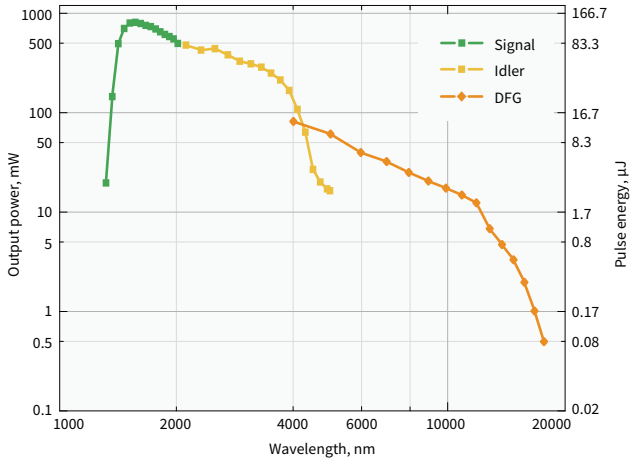
The spectral bandwidth of ORPHEUS-ONE output is defined by the pump laser pulses; thus, for sum-frequency generation (SFG) spectroscopy and other applications requiring broad-bandwidth infrared pulses – refer to ORPHEUS-MIR.



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

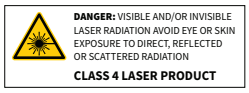
For custom tuning curves visit *http://toolbox.lightcon.com/tools/tuningcurves/*

SPECIFICATIONS

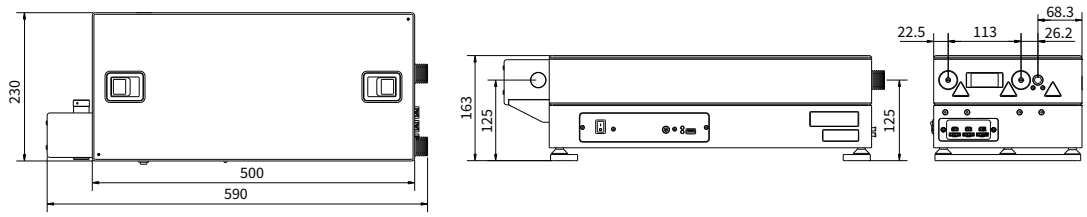
Model	ORPHEUS-ONE	ORPHEUS-ONE-HP	ORPHEUS-ONE-HE
MAIN OUTPUT (1350 – 4500 nm)			
Tuning range	1350 – 2000 nm (Signal) 2100 – 4500 nm (Idler)		
Maximum pump power	8 W	80 W	
Pump pulse energy	12 – 400 µJ	12 – 400 µJ	400 – 2000 µJ
Conversion efficiency at peak [1] **(Signal @ 1550 nm)**	> 9%, 30 – 2000 µJ pump > 6%, 12 – 30 µJ pump		
Spectral bandwidth	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		
WAVELENGTH EXTENSION (4500 – 16000 nm)			
4500 – 16000 nm (DFG) — Conversion efficiency [1]	> 0.3% @ 10000 nm, 30 – 2000 µJ pump > 0.2% @ 10000 nm, 12 – 30 µJ pump		
4500 – 16000 nm (DFG) — Spectral bandwidth	60 – 150 cm^{-1} @ 5000 – 8000 nm	60 – 120 cm^{-1} @ 5000 – 8000 nm	

[1] *Specified as percentage of pump power.*

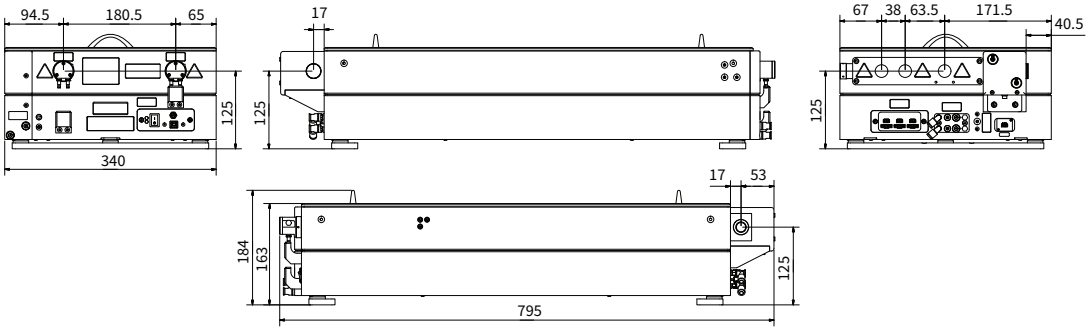
[2] *Expressed as NRMSD (normalized root mean squared deviation).*



DRAWINGS



ORPHEUS-ONE drawings



ORPHEUS-ONE-HP drawings

ORPHEUS | PS

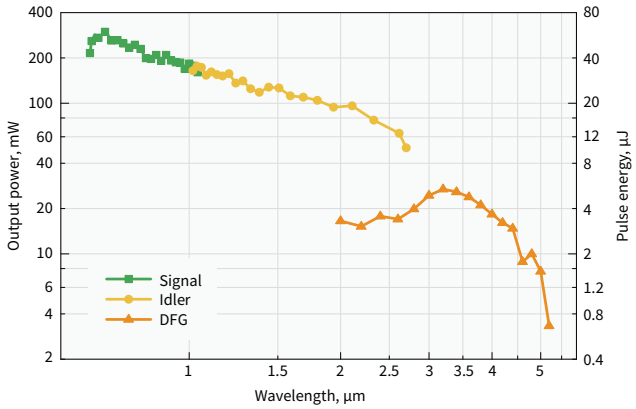
Narrow-Bandwidth Optical Parametric Amplifier

FEATURES

- 210 – 4800 nm tuning range
- 1 – 4 ps pulse duration
- < 20 cm^{-1} spectral bandwidth
- Nearly bandwidth-limited output
- Up to 100 kHz repetition rate
- High output stability

ORPHEUS-PS is a narrow-bandwidth optical parametric amplifier, designed for PHAROS and CARBIDE lasers. ORPHEUS-PS 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, enabling high long-term stability and ease of use. The system also features high conversion efficiency, bandwidth- and diffraction-limited output, and complete 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 set of beams necessary for versatile spectroscopy applications such as femtosecond stimulated Raman spectroscopy (FSRS) and sum-frequency generation (SFG) spectroscopy.

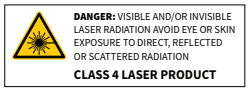


Orpheus-PS tuning curves.
Pump: 5 W, 1000 µJ, 5 kHz from PHAROS-SP.

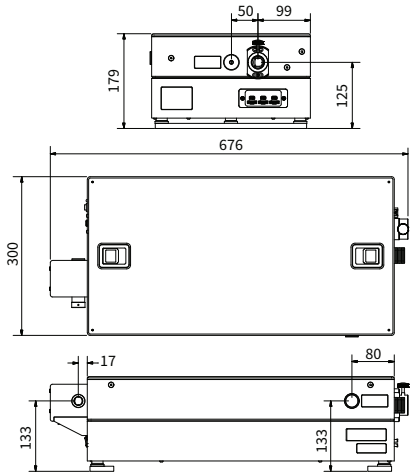
SPECIFICATIONS

Model	ORPHEUS-PS
MAIN OUTPUT	
Tuning range	640 – 1000 nm (Signal) 1060 – 2600 nm (Idler)
Conversion efficiency at peak	> 8% (Signal and Idler combined)
Pulse duration	800 fs – 3 ps
Spectral bandwidth	< 20 cm^{-1} @ 700 – 2000 nm
Pulse-to-pulse energy stability [1]	< 2% @ 700 – 960 nm, 1100 – 1500 nm
AUXILIARY OUTPUT 1 (515 nm)	
Wavelength [2]	515 nm ± 5 nm
Generation efficiency [3]	> 15%
AUXILIARY OUTPUT 2 (1030 nm)	
Wavelength [4]	1030 ± 10 nm
Pulse duration	< 300 fs
Pulse energy	> 5 µJ
WAVELENGTH EXTENSION	
SH package at peak (320 – 500 nm (SHS), 530 – 640 nm (SHI))	> 3%
FH package at peak (210 – 250 nm (FHS), 265 – 320 nm (FHI))	> 0.3% [5]
2400 – 4800 nm (DFG)	> 0.25% @ 3200 nm [5]
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

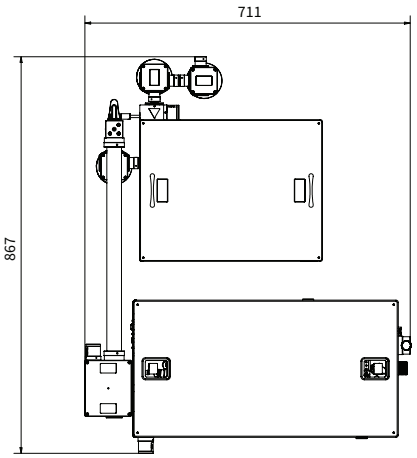
[1] *Expressed as NRMSD (normalized root mean squared deviation).*
[2] *Direct SHBC output, not simultaneous to OPA; see details in SHBC specifications.*
[3] *Specified as percentage of pump pulse energy.*
[4] *Compressed pump output.*
[5] *For > 200 µJ pump pulse energy.*



DRAWINGS



ORPHEUS-PS drawings



ORPHEUS-PS with SHBC drawing

ORPHEUS | TWINS

Dual Optical Parametric Amplifier

FEATURES

- Two simultaneous and independent outputs
- 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 option

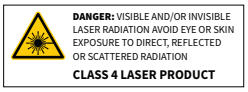
ORPHEUS-TWINS consists of two independently tunable optical parametric amplifiers (OPAs); thus, providing two simultaneous outputs. Integrated into a single housing, both OPAs share the same white-light seed enabling the generation of broadband mid-infrared (MIR) radiation with a passively stable carrier-envelope phase (CEP).

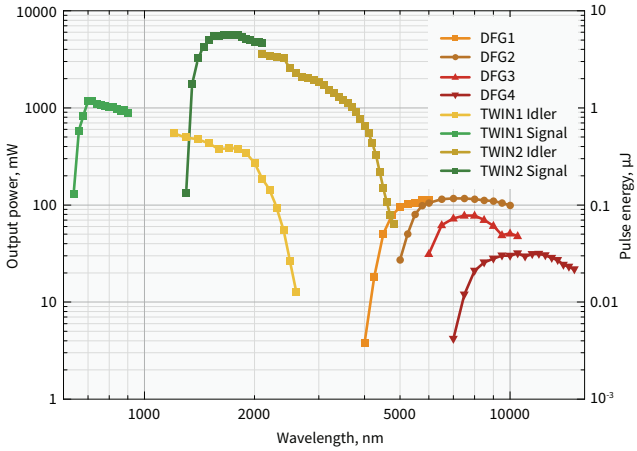
Each of the OPA can be separately configured to be a version of ORPHEUS, ORPHEUS-F, or ORPHEUS-ONE. Check the respective models for more information and detailed specifications.

SPECIFICATIONS

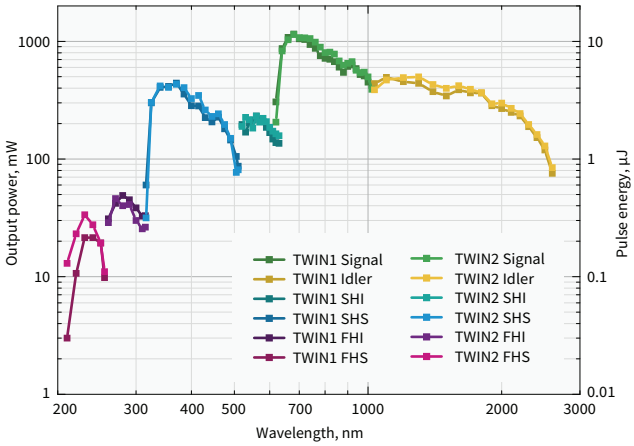
Model	**ORPHEUS-TWINS**
OUTPUT FROM ORPHEUS-TWINS	
Tuning range	Choice between ORPHEUS, ORPHEUS-F, and ORPHEUS-ONE configurations
Output pulse energy	Depends on the configuration, see the specifications of the chosen models
Spectral bandwidth	Depends on configuration, 100 – 750 cm^{-1}
Pulse duration	Depends on configuration, down to 40 fs
Supported repetition rates	Single-shot – 2 MHz
PUMP LASER REQUIREMENTS	
Required pump laser	PHAROS or CARBIDE
Center wavelength	1030 ± 10 nm
Maximum pump power	60 W
Repetition rate	Single-shot – 2 MHz
Pump pulse energy [1)]	16 – 500 µJ
Pulse duration [2)]	180 – 300 fs

[1)] Up to 2 mJ on request.
[2)] FWHM, assuming Gaussian pulse shape.





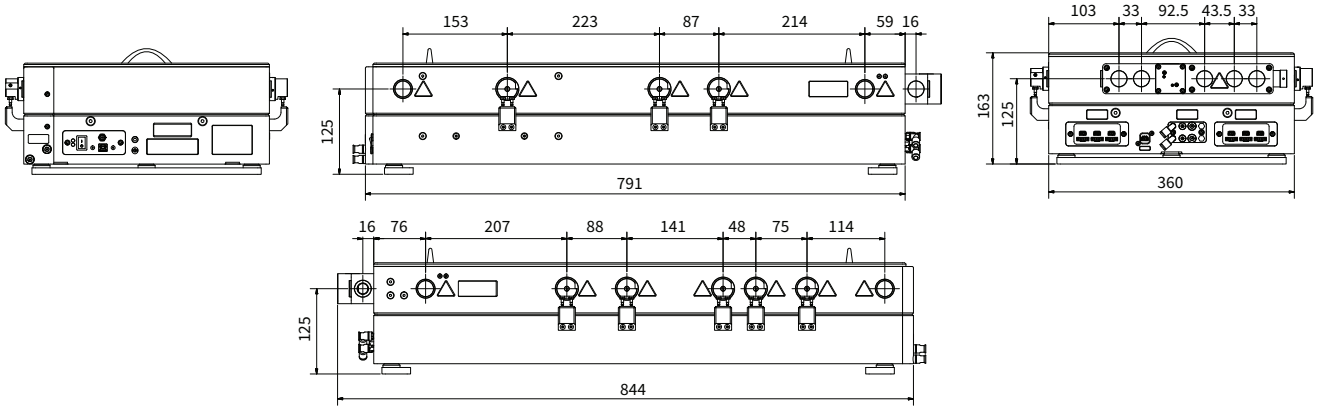
ORPHEUS-TWINS (ONE / F configuration)
tuning curves. Pump: 40 W, 40 µJ, 1 000 kHz



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