EKSPLA

Advanced Laser Technologies

# High Intensity
## Lasers & Laser Systems



*from single shot to kHz repetition rates*

*highly customizable*

# Contents

# About Company

### Background

EKSPLA focuses on the design and manufacturing of advanced lasers & systems and employs 33 years' experience as well as a close partnership with the scientific community. 80 out of the 100 top universities use EKSPLA lasers.

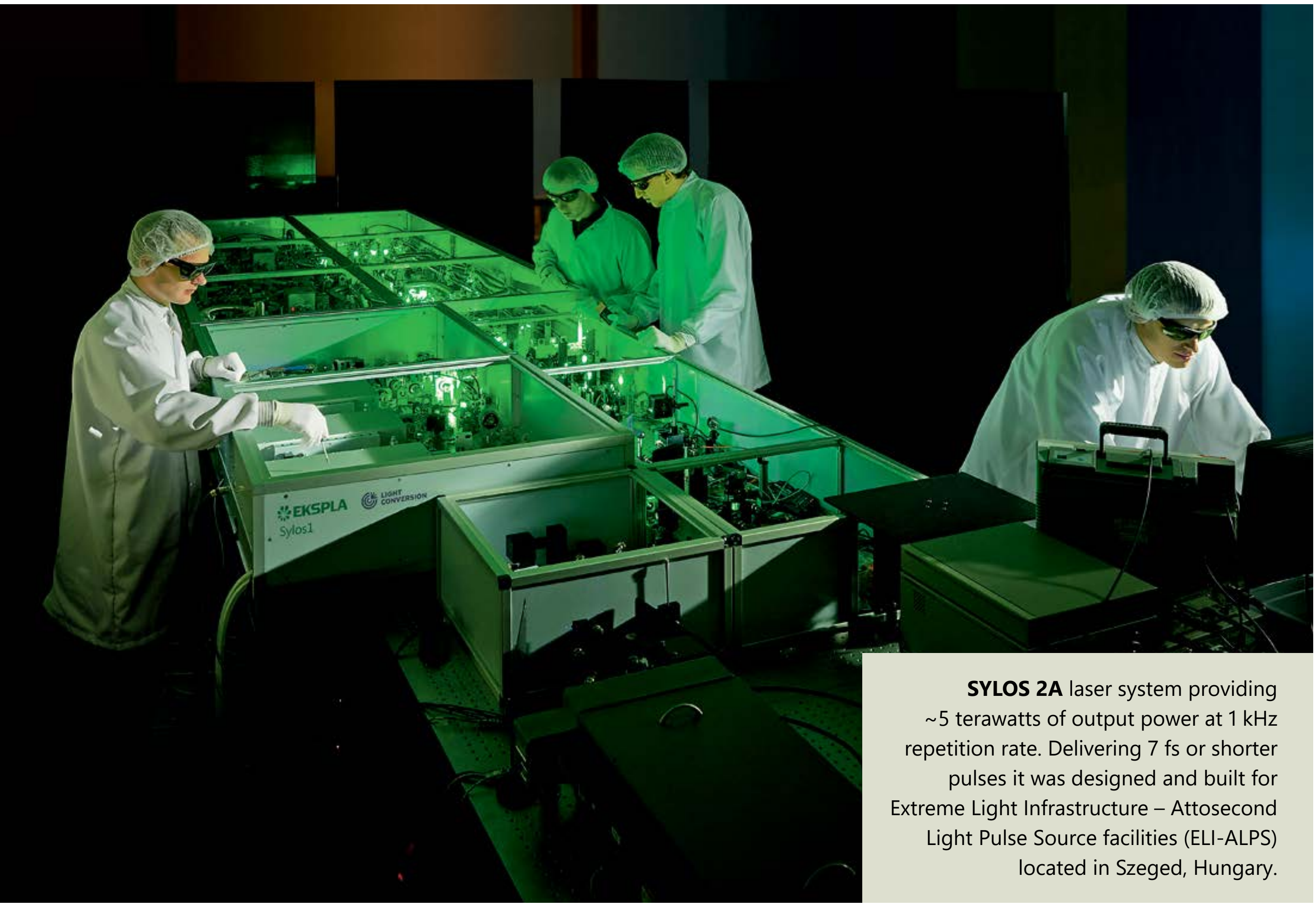
Customers like CERN, NASA, ELI, Max Planck Institutes, Cambridge University, Massachusetts Institute of Technology and Japan University of Science showed trust in EKSPLA lasers & systems.

For scientist who needs unique instrument for research, we provide parameter tailored laser systems that enable customer to perform complex experiments. In-house design and manufacturing ensures operative design, manufacturing and customization of new products.

Highly stable and reliable EKSPLA lasers combined with our own subsidiaries in the US, UK and China as well as more than 20 approved representative offices with properly trained laser engineers worldwide, ensure short response time and fast laser service as well as maintenance.

### History

EKSPLA was founded about 33 years ago by a small team of engineers united around the idea of making the most advanced lasers in the world. EKSPLA was independent company with little money, but lots of creativity, and a deep technical understanding of lasers and how useful they could be for research and industry. From the start, the whole team had a deep mutual respect and believed in and supported each other. The first laser was sold at its first launch event, at an international exhibition in Germany. Soon after, the innovation was noticed by partners in Japan, and supply of the systems to leading universities there has been started. The concept of continuous improvement was admired and embraced, so it has become one of the key principles that apply to everything is done.




**SYLOS 2A** laser system providing ~5 terawatts of output power at 1 kHz repetition rate. Delivering 7 fs or shorter pulses it was designed and built for Extreme Light Infrastructure – Attosecond Light Pulse Source facilities (ELI-ALPS) located in Szeged, Hungary.

# SYLOS 3: High-Intensity Leaps in Fundamental Research

The Single Cycle Laser SYLOS, which employs OPCPA technology, has been designed and manufactured by a consortium of two Lithuanian companies – EKSPLA and Light Conversion. Introduced at Vilnius University, OPCPA today is one of the key technologies for generating high-intensity radiation, surpassing conventional femtosecond technology based on Ti:Sapphire lasers in terms of pumping efficiency, contrast, bandwidth, and, consequently, the degree of control over the generated radiation.

The consortium won SYLOS 1 procurement SYLOS 2A upgrade and SYLO S3 tenders.

SYLOS 2A system was installed in 15 May 2019 and produces Carrier Envelope Phase (CEP) stabilized, 6.6 fs laser pulses with a peak power of > 4.5 TW and an average power of 35 W at 1 kHz repetition rate. At that time it was the highest average power produced by a multi-TW few-cycle OPCPA system.

SYLOS 3 system was installed on September, 2023. Compared to the SYLOS 2A system, the new system provides more than three times higher peak and average power. It delivers 15 TW of peak power at a 1 kHz repetition rate and an 8 fs pulse duration. Kilohertz repetition rate enables researchers to collect significantly more data and, thus, improve the efficiency of experiments.

Learn more about custom TW systems on page 16.

# Unique Laser Systems for Extreme Applications

Today laser intensities reached levels where relativistic effects dominate in laser-matter interaction. New applications of high pulse energy lasers emerge in various disciplines ranging from fundamental physics to materials research and life sciences. EKSPLA presents line of femtosecond, picosecond and nanosecond high pulse energy lasers and amplifiers. Our broad knowledge in high energy laser physics, non-linear materials and more that 30 years of experience in laser design enables us to offer unique solutions for high intensity laser systems.

Our high intensity lasers feature flash lamp pump for ultra-high pulse energy, diode pump for high average power. Innovative solutions for pulse shaping, precise synchronization between different laser sources enable to fit these systems to numerous experiments of modern fundamental science.

## SHORT SELECTION GUIDE

For Your convenience, table contains a short selection guide and highest parameter values achievable. Not all output specifications are available at the same time simultaneously. Please refer to the catalog page for exact specifications and available options.

| Series | Pulse duration | Pulse energy, up to | Repetition rate, up to | Special feature | Page |
|---|---|---|---|---|---|
| **UltraFlux HR** | down to 10 fs | 20 mJ | 1 kHz | High repetition rate Tunable Wavelength fs OPCPA Systems | 5 |
| **UltraFlux HE** | | 1 J | 100 Hz | High Energy fs OPCPA Systems | 10 |
| **UltraFlux Custom** | down to 8 fs | 1 J | 1 kHz | Custom multi TW Few cycle OPCPA systems | 16 |
| **PicoFlux HE** | 90 ± 10 ps | 2.2 J | 10 Hz | High energy flash lamp pumped ps amplifiers | 24 |
| **PicoFlux HP** | | 130 mJ | 1 kHz | High power DPSS ps amplifiers | 24 |
| **PicoFlux Custom** | | 2.2 J per channel | 10 kHz | Custom multi-channel, burst mode and 1 ps Ytterbium amplifier systems | 28 |
| **NanoFlux SLM** | 2 ± 0.5 ns | 10 J | 10 Hz | High energy Single Longitudinal Mode (SLM) Nd:YAG lasers | 32 |
| **NanoFlux MM** | 5 ± 1 ns | 10 J | 10 Hz | High energy Multi-Mode Nd:YAG lasers | 36 |
| **NanoFlux HP** | | 5 J | 1 kHz | High power DPSS ns amplifier systems | 40 |
| **NanoFlux AWG** | 0.15 – 20 ns | 10 J | 10 Hz | High energy systems with temporal pulse shaping (AWG) | 44 |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# High repetition rate Tunable Wavelength Femtosecond OPCPA Systems

## UltraFlux HR
### SERIES

UltraFlux HR series is a compact high repetition rate tunable wavelength femtosecond laser system which incorporates the advantages of dual output ultrafast fiber laser, solid-state and parametric chirped pulse amplification technologies.

A novel OPCPA front-end technology uses a dual output picosecond fiber laser for seeding both picosecond DPSS pump laser and femtosecond parametric amplifier with a spectrally broadened output.

This approach greatly simplifies the system – excludes femtosecond regenerative amplifier and eliminates the need of pump and seed pulse synchronization while ensuring practically zero jitter between the channels. In addition to that, contrast of the output pulses in picosecond to nanosecond time scale is enhanced.

All UltraFlux series laser systems are assembled on a rigid breadboard or optical table to ensure excellent long-term stability. Modular internal design offers high level of customization and easy scalability. All of these systems can be customized according to customer requirements by adding custom specifications or multiple channels.

Incorporation of parametric chirped pulse amplification technology together with a novel ultrafast fiber laser helped to create and bring to the market a new tool for femtosecond pump-probe, nonlinear spectroscopy, emerging high harmonic generation experiments and other femtosecond and nonlinear spectroscopy applications. With this laser ultrafast science breakthrough is closer to any photonics lab than ever before.

### FEATURES

- *Based on the novel OPCPA (Optical Parametric Chirped Pulse Amplification) technology*
- *Patented front-end design (patents no. EP2827461 and EP2924500)*
- *750 – 960 nm, 375 – 480 nm, 250 – 320 nm and 210 – 230 nm wavelength tuning ranges*
- *Up to 14 mJ pulse energy at 1 kHz repetition rate*
  - *Excellent pulse energy stability: ≤ 1 % RMS*
  - *Excellent long-term average power stability: ≤ 1.5 % RMS over 8-hour period*
- *Perfectly synchronized fs and ps output option available*
- *Hands free wavelength tuning*
- *High contrast pulses without any additional improvement equipment*

### APPLICATIONS

- *Broadband CARS and SFG*
- *Femtosecond pump-probe spectroscopy*
- *Nonlinear spectroscopy*
- *High harmonic generation*

## SPECIFICATIONS

| Model | FT031k | FT31k | FT61k | FT141k |
|---|---|---|---|---|
| **MAIN SPECIFICATIONS** [1] | | | | |
| Output energy [2] | | | | |
| Signal | 300 µJ | 3 mJ | 6 mJ | 14 mJ |
| SH output [3] | 60 µJ | 0.6 mJ | 1.5 mJ | 3.5 mJ [4] |
| TH output [3] | 15 µJ | 150 µJ | 0.4 mJ | 1.2 mJ [4] |
| FH output [3] | 3 µJ | 30 µJ | 100 µJ | 300 µJ [4] |
| Pulse repetition rate | 1 kHz | 1 kHz | 1 kHz | 1 kHz |
| Wavelength tuning range | | | | |
| Signal [5] | 750 – 960 nm | 750 – 960 nm | 750 – 960 nm | 750 – 960 nm |
| SH output [3] | 375 – 480 nm | 375 – 480 nm | 375 – 480 nm | 375 – 480 nm |
| TH output [3] | 250 – 320 nm | 250 – 320 nm | 250 – 320 nm | 250 – 320 nm |
| FH output [3] | 210 – 230 nm | 210 – 230 nm | 210 – 230 nm | 210 – 230 nm |
| Scanning steps | | | | |
| Signal | 5 nm | 5 nm | 5 nm | 5 nm |
| SH output [3] | 5 nm | 5 nm | 5 nm | 5 nm |
| TH output [3] | 3 nm | 3 nm | 3 nm | 3 nm |
| FH output [3] | 2 nm | 2 nm | 2 nm | 2 nm |
| Pulse duration [5] [7] | 40 ± 20 fs | 40 ± 20 fs | 40 ± 20 fs | 40 ± 20 fs |
| Pulse energy stability [8] | ≤ 1.5 % | ≤ 1 % | ≤ 1 % | ≤ 1 % |
| Long-term power drift [9] | ± 1.5 % | ± 1.5 % | ± 1.5 % | ± 1.5 % |
| Beam spatial profile | Gaussian | Super-Gaussian [10] | Super-Gaussian [10] | Super-Gaussian [10] |
| Beam diameter [11] | ~ 2 mm | ~ 5 mm | ~ 7 mm | ~ 15 mm |
| Beam pointing stability [12] | ≤ 20 µrad | ≤ 20 µrad | ≤ 20 µrad | ≤ 20 µrad |
| Temporal contrast [13] | | | | |
| APFC (within ± 50 ps) | > $10^{10}$ : 1 | > $10^{10}$ : 1 | > $10^{10}$ : 1 | > $10^{10}$ : 1 |
| Pre-pulse (50 – 10 ps) | > $10^{8}$ : 1 | > $10^{8}$ : 1 | > $10^{8}$ : 1 | > $10^{8}$ : 1 |
| Pre-pulse (10 – 1 ps) | > $10^{6}$ : 1 | > $10^{6}$ : 1 | > $10^{6}$ : 1 | > $10^{6}$ : 1 |
| Post-pulse (beyond 20 ps) | > $10^{6}$ : 1 | > $10^{6}$ : 1 | > $10^{6}$ : 1 | > $10^{6}$ : 1 |
| Optical pulse jitter [14] | | | | |
| Trig out | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps |
| Pre-Trig out | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps |
| With –PLL option | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps |
| Polarization | Linear, Horizontal | Linear, Horizontal | Linear, Horizontal | Linear, Horizontal |
| **PHYSICAL CHARACTERISTICS** [15] | | | | |
| Laser head size (W×L×H mm) | 750 × 1200 × 300 | 900 × 1500 × 300 | 900 × 1800 × 300 | 1200 × 2000 × 300 |
| Power supply size (W×L×H mm) | 553 × 600 × 850 | 553 × 600 × 850 | 553 × 600 × 850 | 553 × 600 × 1250 |
| Umbilical length [16] | 2.5 m | 2.5 m | 2.5 m | 2.5 m |
| **OPERATING REQUIREMENTS** [17] | | | | |
| Electrical power | 200 – 240 V AC, single-phase, 47 – 63 Hz | 200 – 240 V AC, single-phase, 47 – 63 Hz | 208, 380 or 400 V AC, three-phase, 50/60 Hz [18] | 208, 380 or 400 V AC, three-phase, 50/60 Hz [18] |
| Power consumption [19] | ≤ 1 kW | ≤ 2 kW | ≤ 5 kW | ≤ 8 kW |
| Water supply | not required | not required | not required | ≤ 5 l/min, 2 Bar, max 20 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 | ISO Class 7 |

[1] Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements.

[2] Maximum pulse energy specified at 840 nm, SH output at 420 nm, TH output at 280 nm and FH output at 210 nm.

[3] Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous. Maximum harmonic energy depends on OPCPA signal beam profile and pulse duration.

4) Maximum pump energy for harmonics limited to 10 mJ @ 840 nm.

5) Optional extended tuning range of 700 – 1010 nm available upon request.

6) Standard pulse duration changes though the wavelength range – shortest pulse duration is achieved ~840 nm spectral range.

7) Separate 'F10' option can be ordered to reduce pulse duration to ≤ 10 fs. Wavelength tunability not available with 'F10' option.

8) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

9) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

10) Super-Gaussian spatial mode of 6-11$^{th}$ order in near field.

11) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

12) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 30 s).

13) Pulse contrast is only limited by amplified parametric fluorescence (APFC) in the temporal range of ~90 ps which covers OPCPA pump pulse duration and is better than $10^7$:1. APFC contrast depends on OPCPA saturation level. Our OPCPA systems are ASE-free and pulse contrast value in nanosecond range is limited only by measurement device capabilities (third-order autocorrelator). There are no pre-pulses generated in the system and post-pulses are eliminated by using wedged transmission optics.

14) Optical pulse jitter with respect to electrical outputs:
– Trig out > 3.5 V @ 50 Ω
– Pre-Trig out > 1 V @ 50 Ω
– PLL option > 1 V @ 50 Ω

15) System sizes are preliminary and depend on customer lab layout and additional options purchased.

16) Longer umbilical with up to 10 m for flash lamp pumped and up to 5 m for diode pumped systems available upon request.

17) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

18) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

19) Required current rating can be calculated by dividing power rating by mains voltage. Power rating is given in apparent power (kVA) for systems with flash lamp power supplies and in real power (kW) for systems without flash lamp power supplies where reactive power is neglectable.

## OPTIONS

| Option | Description | Comment |
|---|---|---|
| -F10 | Short Pulse option reduces output pulse duration to ≤ 10 fs | Wavelength tunability not available with 'F10' option |
| -CEP | CEP stabilization to ≤ 400 mrad | Passive and active CEP stabilization |
| -DM | 'Deformable Mirror' option for Strehl ration improvement to > 0.9 | |
| -SH/TH/FH | Second, third and fourth harmonic outputs | Conversion efficiency from signal respectively ~20 %, ~5 % and ~1 %. Harmonic outputs are not simultaneous with signal output |
| -ps out | Additional ps output that is optically synchronized to main system output | Can be simultaneous and non-simultaneous to the main system output |
| -AW | Air-Water cooling | No external water required. Heat dissipation equals total power consumption |

## PERFORMANCE

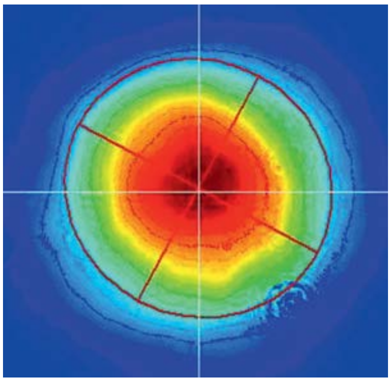

*Fig 1.* Typical UltraFlux FT031k near field beam profile

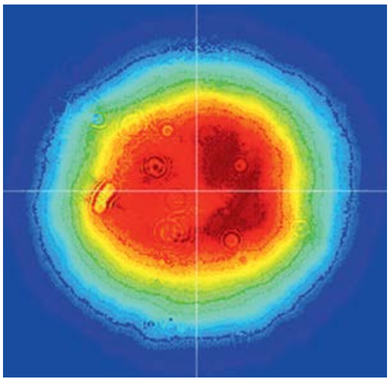

*Fig 2.* Typical UltraFlux FT31k near field beam profile

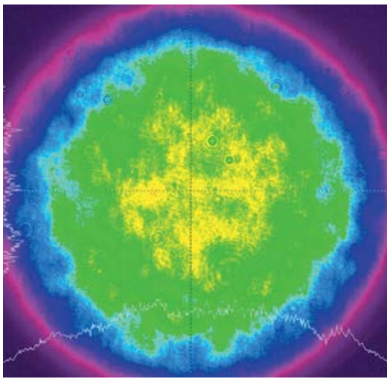

*Fig 3.* Typical UltraFlux FT61k and FT141k near field beam profile

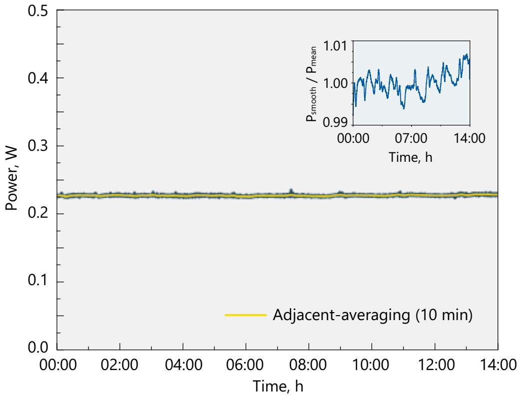


*Fig 4.* Long-term power stability measurement at 800 nm wavelength

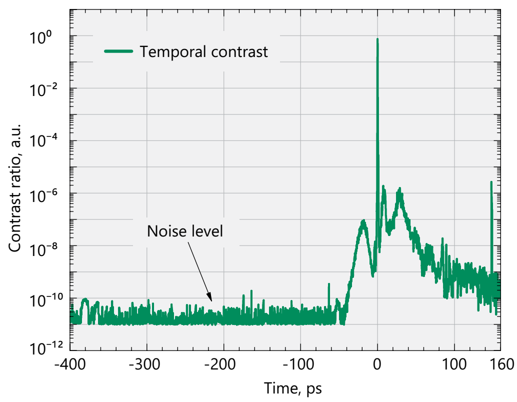


*Fig 5.* Typical temporal contrast of UltraFlux systems

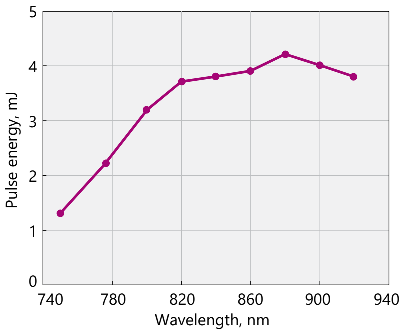


*Fig 6.* Typical energy tuning curve of UltraFlux FT31k laser system

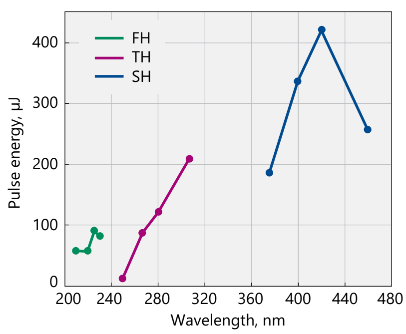


*Fig 7.* Typical energy tuning curves of UltraFlux FT31k second, third and fourth harmonic outputs

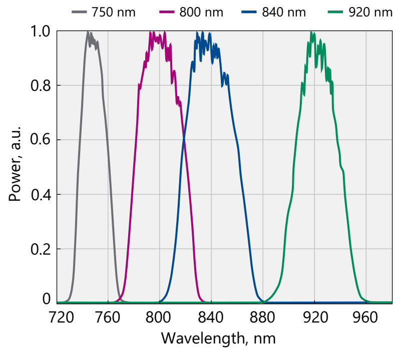


*Fig 8.* Typical output spectra of UltraFlux FT31k system at multiple wavelengths


*Fig 9.* Typical external view of UltraFlux FT031k system (actual design might vary)

## OUTLINE DRAWINGS

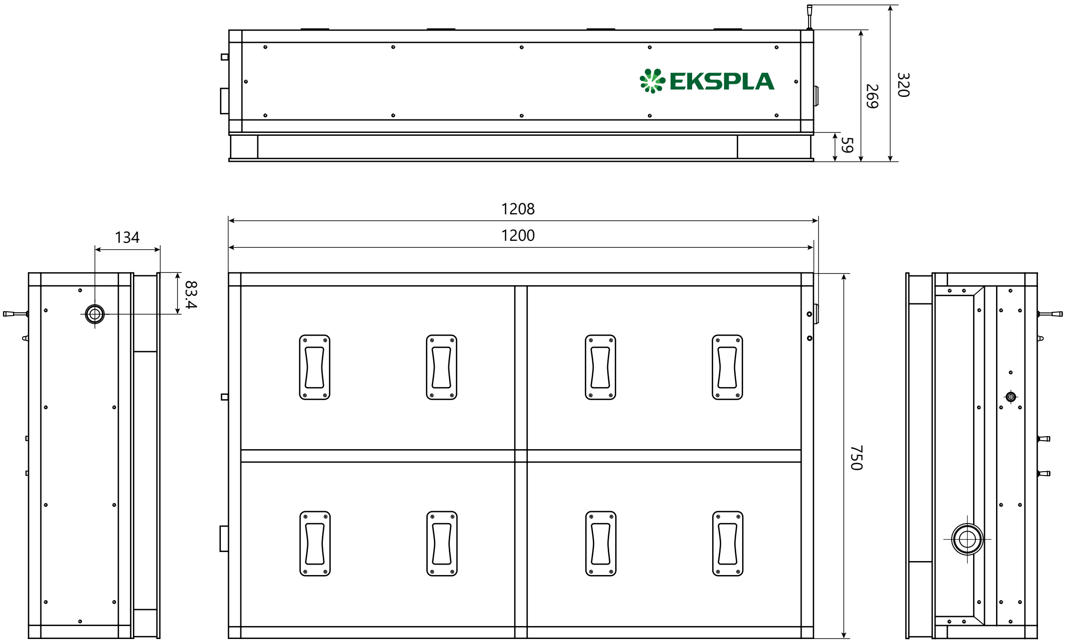


*Fig 10.* Typical UltraFlux FT031k laser system external dimensions

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm | Width W, mm | Depth D, mm |
|---|---|---|---|---|
| MR-9 | 9 U | 455.5 (519 [1]) | 553 | 600 |
| MR-12 | 12 U | 589 (653 [1]) | 553 | 600 |
| MR-16 | 16 U | 768 (832 [1]) | 553 | 600 |
| MR-20 | 20 U | 889 (952 [1]) | 553 | 600 |
| MR-25 | 25 U | 1167 (1231 [1]) | 553 | 600 |

[1] Full height with wheels.

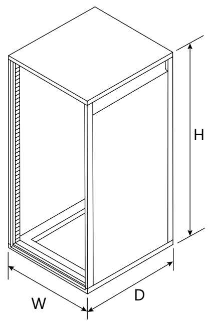


*Fig 11.* Typical UltraFlux laser system power supply dimensions (MR rack used depends on the laser model)

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

**UltraFlux (1) (2)(3)-(4)**

Fixed or tunable wavelength:
FF → fixed wavelength
FT → tunable wavelength

Energy level:
03 → 300 μJ
3 → 3 mJ
6 → 6 mJ
14 → 14 mJ

Pulse repetition rate:
1k → 1 kHz

Any additional options:
See 'Options' table

# High Energy Femtosecond OPCPA Systems

# UltraFlux HE
## SERIES


**UltraFlux FF.** Custom high pulse energy femtosecond fixed wavelength laser systems delivering up to 1 J pulse energy with pulse duration down to 10 fs.

High Energy UltraFlux laser series delivers up to **30 TW** peak power operating up to 10 Hz.

Originally built for ELI-ALPS (Extreme Light Infrastructure – Attosecond Light Pulse Source) in Hungary, this series is now available for a wide variety of applications.

The master oscillator is a patented (no. EP2827461 and EP2924500) all-in-fiber Yb doped picosecond laser seed source with two fiber outputs. One seeds the OPCPA Front-End and another seeds the Picosecond Pump Laser. Both outputs originate from the same fiber so they are optically synchronized.

This approach eliminates the need for a complex temporal synchronization system typically present in other OPCPA systems.

The Nd:YAG Picosecond Pump Laser system (PPL) is comprised of several sub-systems: diode pumped Regenerative Amplifier, diode pumped Preamplifier, flash lamp pumped Amplifiers, and Second Harmonic Generators which convert fundamental 1064 nm wavelength to 532 nm. PPL outputs multiple beams at 532 nm. One beam is directed to NOPCPA Front-End subsystem and others are directed to NOCPA amplification stages.

The Front-End NOPCPA (Non-collinear Optical Parametric Chirped Pulse Amplifier) consists of several sub-systems: Picosecond Optical Parametric Amplifier (ps-OPA) amplifying oscillator output pulses, Grating Compressor compressing ps-OPA output pulses, White Light Generator (WLG) broadening the spectrum of ps-OPA output pulses and Femtosecond Non-collinear Optical Parametric Amplifier (fs-NOPA) amplifying WLG output pulses.

The Stretcher sub-system is a Grism (diffraction gratings combined together with prisms) or Offner type pulse stretcher, which stretches output pulse from NOPCPA Front-End and Dazzler (optional Acousto-Optic Programmable Dispersive Filter) for high order phase compensation.

## FEATURES

- *Based on the novel **OPCPA** (Optical Parametric Chirped Pulse Amplification) technology*
- *Patented front-end design (patents no. EP2827461 and EP2924500)*
- *Up to **1 J** pulse energy at **5 Hz** repetition rate*
- *From **Single Shot** to **100 Hz** pulse repetition rate*
- *Down to **10 fs** pulse duration*
- *Up to **50 mJ** pulse energy at **100 Hz** repetition rate*
  - *Excellent pulse energy stability: ≤ **1 %** RMS*
  - *Excellent long-term average power stability: ≤ **1.5 %** RMS over **8-hour** period*
- *Perfectly synchronized fs and ps output option available*
- *Hands free wavelength tuning*
- *High contrast pulses without any additional improvement equipment*

## APPLICATIONS

- *Broadband CARS and SFG*
- *Femtosecond pump-probe spectroscopy*
- *Nonlinear spectroscopy*
- *High harmonic generation*
- *Wake field particle acceleration*
- *X-ray generation*

# UltraFlux HE



Multiple stages of NOPCPA (Non-collinear Optical Parametric Chirped Pulse Amplifiers) are used to amplify the stretched pulse from the Stretcher up to 1 J.

Finally, amplified pulses are compressed back down to fs duration in the Pulse Compressor. Bulk glass compressor (combined together with chirped mirror) or traditional diffraction grating compressor can be used depending on pulse duration required and output energy level.

The built-in Output Diagnostics stage ensures reliable, turn-key operation by monitoring critical parameters such as energy, duration, and beam profile.

## SPECIFICATIONS

| Model | FT310 | FT10010 | FF50100-F10 | FF8005 |
|---|---|---|---|---|
| **MAIN SPECIFICATIONS** [1] | | | | |
| Output energy [2] | | | | |
| Signal | 3 mJ | 100 mJ | 50 mJ | 800 mJ |
| SH output [3] | 0.6 mJ | 3.5 mJ [4] | 3.5 mJ [4] | 3.5 mJ [4] |
| TH output [3] | 150 µJ | 1.2 mJ [4] | 1.2 mJ [4] | 1.2 mJ [4] |
| FH output [3] | 30 µJ | 300 µJ [4] | 300 µJ [4] | 300 µJ [4] |
| Pulse repetition rate | 10 Hz | 10 Hz | 100 Hz | 5 Hz |
| Wavelength tuning range | | | | |
| Signal | 750 – 960 nm | 750 – 960 nm | 840 nm | 840 nm |
| SH output [3] | 375 – 480 nm | 375 – 480 nm | 420 nm | 420 nm |
| TH output [3] | 250 – 320 nm | 250 – 320 nm | 280 nm | 280 nm |
| FH output [3] | 210 – 230 nm | 210 – 230 nm | 210 nm | 210 nm |
| Scanning steps | | | | |
| Signal | 5 nm | 5 nm | – | – |
| SH output [3] | 5 nm | 5 nm | – | – |
| TH output [3] | 3 nm | 3 nm | – | – |
| FH output [3] | 1 nm | 1 nm | – | – |
| Pulse duration [5] [6] | 40 ± 20 fs | 40 ± 20 fs | ≤ 10 fs | 40 ± 20 fs |
| Pulse energy stability [7] | ≤ 1.5 % | ≤ 1.5 % | ≤ 1 % | ≤ 1.5 % |
| Long-term power drift [8] | ± 1.5 % | ± 1.5 % | ± 1.5 % | ± 1.5 % |
| Beam spatial profile | Super-Gaussian [9] | Super-Gaussian [9] | Super-Gaussian [9] | Super-Gaussian [9] |
| Beam diameter [10] | ~ 5 mm | ~ 30 mm | ~ 80 mm | ~ 70 mm |
| Beam pointing stability [11] | ≤ 20 µrad | ≤ 20 µrad | ≤ 20 µrad | ≤ 20 µrad |
| Temporal contrast [12] | | | | |
| APFC (within ± 50 ps) | > $10^{10}$ : 1 | > $10^{10}$ : 1 | > $10^{10}$ : 1 | > $10^{10}$ : 1 |
| Pre-pulse (50 – 10 ps) | > $10^{8}$ : 1 | > $10^{8}$ : 1 | > $10^{8}$ : 1 | > $10^{8}$ : 1 |
| Pre-pulse (10 – 1 ps) | > $10^{6}$ : 1 | > $10^{6}$ : 1 | > $10^{6}$ : 1 | > $10^{6}$ : 1 |
| Post-pulse (beyond 20 ps) | > $10^{6}$ : 1 | > $10^{6}$ : 1 | > $10^{6}$ : 1 | > $10^{6}$ : 1 |
| Optical pulse jitter [13] | | | | |
| Trig out | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps |
| Pre-Trig out | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps |
| With –PLL option | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps |
| Polarization | Linear | Linear | Linear | Linear |
| **PHYSICAL CHARACTERISTICS** [14] | | | | |
| Laser head size (W×L×H mm) | 900 × 1500 × 300 | 1200 × 2000 × 300 | 1200 × 3600 × 500 | 1500 × 2000 × 500, 2 pc.<br>1200 × 2500 × 500 |
| Power supply size (W×L×H mm) | 553 × 600 × 850 | 553 × 600 × 1200 | 553 × 600 × 1020<br>553 × 600 × 500 | 553 × 600 × 1800, 2 pc.<br>553 × 600 × 500 |
| Umbilical length [15] | 5 m | 5 m | 2.5 m | 5 m |

Femtosecond Lasers

Picosecond Lasers

Nanosecond Lasers

| Model | FT310 | FT10010 | FF50100-F10 | FF8005 |
|---|---|---|---|---|
| **OPERATING REQUIREMENTS** [16] | | | | |
| Electrical power | 200 – 240 V AC, single-phase, 47 – 63 Hz | 200 – 240 V AC, single-phase, 47 – 63 Hz | 208, 380 or 400 V AC, three-phase, 50/60 Hz [17] | 208, 380 or 400 V AC, three-phase, 50/60 Hz [17] |
| Power consumption [18] | ≤ 1 kVA | ≤ 3.5 kVA | ≤ 6 kVA | ≤ 11 kVA |
| Water supply | ≤ 3 l/min, 2 Bar, max 20 °C | ≤ 6 l/min, 2 Bar, max 20 °C | ≤ 10 l/min, 2 Bar, max 20 °C | ≤ 14 l/min, 2 Bar, max 15 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements.

2) Maximum pulse energy specified at 840 nm, SH output at 420 nm, TH output at 280 nm and FH output at 210 nm.

3) Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous. Maximum harmonic energy depends on OPCPA signal beam profile and pulse duration.

4) Maximum pump energy for harmonics is limited to 10 mJ @ 840 nm.

5) Standard pulse duration changes though the wavelength range – shortest pulse duration is achieved ~840 nm spectral range.

6) Separate 'F10' option can be ordered to reduce pulse duration to ≤ 10 fs. Wavelength tunability not available with 'F10' option.

7) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

8) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

9) Super-Gaussian spatial mode of 6-11th order in near field.

10) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

11) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

12) Pulse contrast is only limited by amplified parametric fluorescence (APFC) in the temporal range of ~90 ps which covers OPCPA pump pulse duration. APFC contrast depends on OPCPA saturation level. Our OPCPA systems are ASE-free and pulse contrast value in nanosecond range is limited only by measurement device capabilities (third-order autocorrelator). There are no pre-pulses generated in the system and post-pulses are eliminated by using wedged transmission optics.

13) Optical pulse jitter with respect to electrical outputs:
– Trig out > 3.5 V @ 50 Ω
– Pre-Trig out > 1 V @ 50 Ω
– PLL option > 1 V @ 50 Ω

14) System sizes are preliminary and depend on customer lab layout and additional options purchased.

15) Longer umbilical with up to 10 m for flash lamp pumped and up to 5 m for diode pumped systems available upon request.

16) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

17) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

18) Required current rating can be calculated by dividing power rating by mains voltage. Power rating is given in apparent power (kVA) for systems with flash lamp power supplies and in real power (kW) for systems without flash lamp power supplies where reactive power is neglectable.

## OPTIONS

| Option | Description | Comment |
|---|---|---|
| -F10 | Short Pulse option reduces output pulse duration to ≤ 10 fs | Wavelength tunability not available with 'F10' option |
| -CEP | CEP stabilization to ≤ 400 mrad | Passive and active CEP stabilization |
| -DM | 'Deformable Mirror' option for Strehl ration improvement to > 0.9 | |
| -SH/TH/FH | Second, third and fourth harmonic outputs | Typical conversion efficiency from signal is ~35 %, ~12 % and ~3 % respectively and depends on beam profile and pulse duration of the system. Harmonic outputs are not simultaneous with signal output |
| -ps out | Additional narrow spectra ps output that is optically synchronized to main system output | Can be simultaneous and non-simultaneous to the main system output. Offers full optical synchronization to fs pulses |
| -AW | Air-Water cooling | No external water required. Heat dissipation equals total power consumption |

## PERFORMANCE

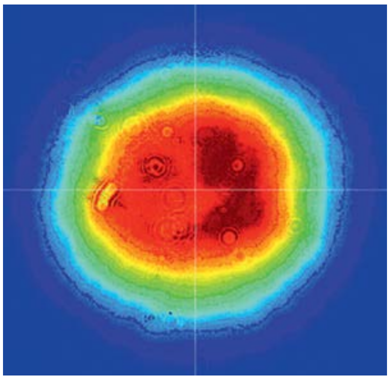

*Fig 1.* Typical UltraFlux FT310 near field beam profile

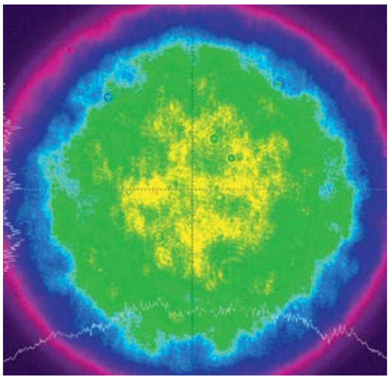

*Fig 2.* Typical UltraFlux FT10010 and FF50100-F10 near field beam profile

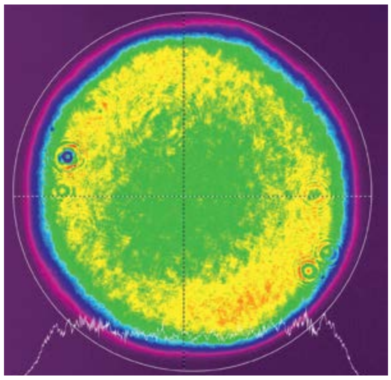

*Fig 3.* Typical UltraFlux FF8005 near field beam profile

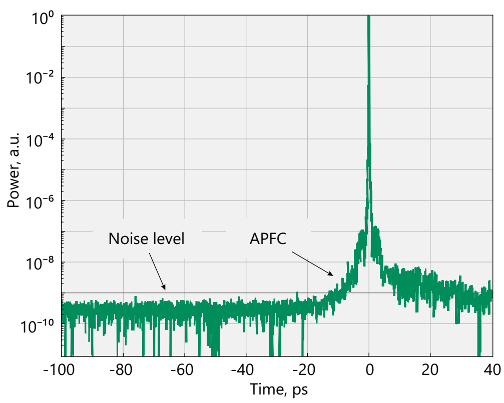


*Fig 4.* Typical temporal contrast of UltraFlux FF10010 system

# UltraFlux HE



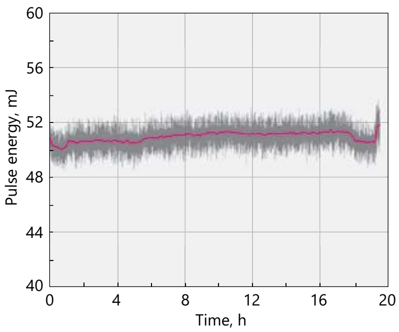


*Fig 5.* Typical long-term power stability of UltraFlux FF5010-F10 system at 840 nm

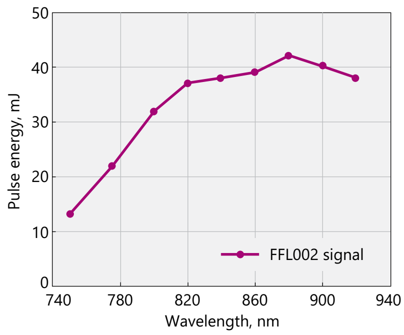


*Fig 6.* Typical tuning curve of UltraFlux FT4010 laser system

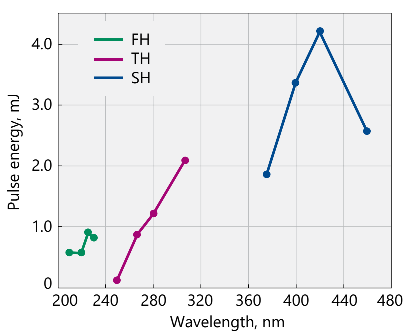


*Fig 7.* Typical energies of UltraFlux FT4010 second, third and fourth harmonic outputs

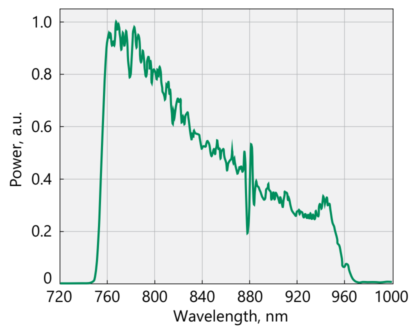


*Fig 8.* Typical output spectra of UltraFlux FF5010-F10 system

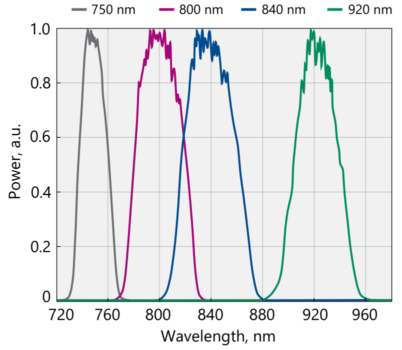


*Fig 9.* Typical output spectra of UltraFlux FF5010 system at different wavelengths

## OUTLINE DRAWINGS


*Fig 10.* Typical external view of UltraFlux FF5010-F10 system (actual design might vary)

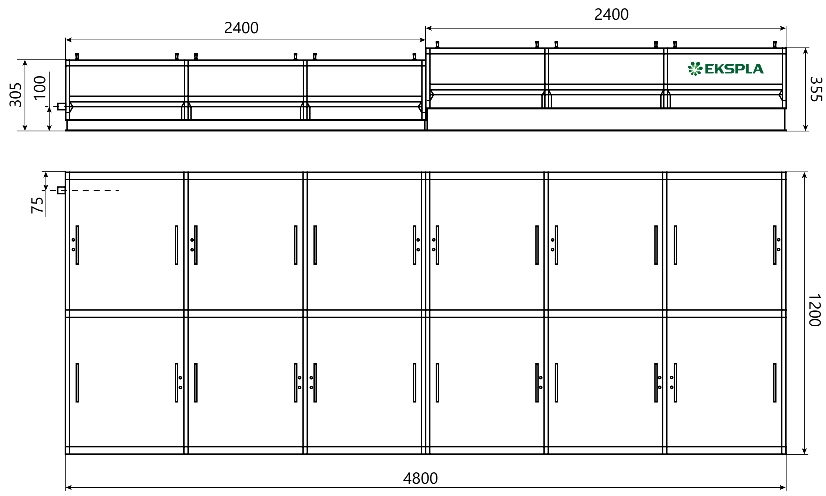


*Fig 11.* Typical UltraFlux FF5010-F10 laser system external dimensions

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm | Width W, mm | Depth D, mm |
|---|---|---|---|---|
| MR-9 | 9 U | 455.5 (519 [1]) | 553 | 600 |
| MR-12 | 12 U | 589 (653 [1]) | 553 | 600 |
| MR-16 | 16 U | 768 (832 [1]) | 553 | 600 |
| MR-20 | 20 U | 889 (952 [1]) | 553 | 600 |
| MR-25 | 25 U | 1167 (1231 [1]) | 553 | 600 |

[1] Full height with wheels.

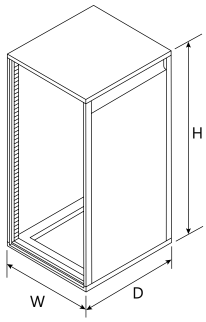


*Fig 12.* Typical UltraFlux laser system power supply dimensions (MR rack used depends on the laser model)

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

**UltraFlux (1) (2)(3)-(4)**

Fixed or tunable wavelength:
FF → fixed wavelength
FT → tunable wavelength

Energy level:
3 → 3 mJ
50 → 50 mJ
100 → 100 mJ
800 → 800 mJ

Pulse repetition rate:
5 → 5 kHz
10 → 10 Hz
100 → 100 Hz

Any additional options:
See 'Options' table

# Multi TW Few cycle OPCPA systems

# UltraFlux Custom


Unique OPCPA based laser system, providing ~15 terawatts of output power at 1 kHz repetition rate and an 8 fs pulse duration. Has been designed and built for ELI-ALPS facilities located in Szeged, Hungary

Since their invention, lasers have been extremely effective to improve our understanding of the molecular and atomic structure of matter and the associated dynamical events. However, laser pulse energy was not enough to probe deeper – into nucleons and their components the quarks or to dissociate the vacuum. A new type of large-scale laser infrastructure specifically designed to produce the highest peak power and focused intensity was established by the European Community: the Extreme Light Infrastructure (ELI). ELI was designed to be the first exawatt class laser facility, equivalent to 1000 times the National Ignition Facility (NIF) power. Producing kJ of power over 10 fs, ELI will afford wide benefits to society ranging from improvement of oncology treatment, medical and biomedical imaging, fast electronics and our understanding of aging nuclear reactor materials to development of new methods of nuclear waste processing.

The facility will be based on four sites. Three of them are implemented in the Czech Republic, Hungary and Romania.

ELI-ALPS based in Szeged (Hungary), one of the three pillars of the Extreme Light Infrastructure, will further deepen knowledge in fundamental physics by providing high repetition rate intense light pulses on the attosecond timescale. Current technological limitations will be overcome by use of novel concepts. The main technological backbone of ELI-ALPS will be optical parametric chirped-pulse amplification (OPCPA) of few-cycle to sub-cycle laser pulses.

Pumped by dedicated all-solid-state short-pulse (ps-scale) sources and their (low-order) harmonics, this approach will be competitive with conventional (Ti:Sapphire laser based) femtosecond technology in terms of pumping efficiency and will dramatically outperform previous technologies in terms of average

## FEATURES

- *Driven by low maintenance cost diode-pumped and industry-tested Yb:KGW and Nd:YAG lasers running at 1 kHz repetition rate*
- *> **120 W** average power combined with > **15 TW** peak power, along with sub-250 mrad carrier-envelope phase stability (CEP) and **sub-8 fs** pulse duration at a center wavelength of **900 nm***
- *Amplified Spontaneous Emission (ASE) – free, passively CEP stabilized pulses have excellent stability of output parameters over 24 hours of continuous operation*
- *Despite its unique set of specifications, it is still a table-top system*
- *A sophisticated self-diagnostic system allows hands-free operation and output specification stability all day long without operator intervention*

## APPLICATIONS

- *Fundamental frontier particle physics research*
- *Nuclear Photonics*
- *High harmonic generation*
- *Attosecond pulse generation*
- *Wake field particle acceleration*
- *X-ray generation*

# UltraFlux Custom



power, contrast, bandwidth, and – as a consequence – degree of control of the generated radiation. The ELI-ALPS laser architecture will consist of three main laser beamlines, operating at different regimes of repetition rates and peak powers: High Repetition Rate (HR): 100 kHz, > 5 mJ, ≤ 6 fs, Single Cycle (SYLOS): 1 kHz, > 120 mJ, ≤ 8 fs, High Field (HF): 10 Hz, 34 J, ≤ 17 fs.

The Single Cycle Laser SYLOS laser system is based on OPCPA (Optical Parametric Chirped-Pulse Amplification) technology, developed at Vilnius university.

Unlike other TW-level systems available in the market that operate in a single-shot or low repetition rate mode, SYLOS 3 will run at a 1 kHz repetition rate. With this novel approach, researchers will be able to collect significantly more data and transition from fundamental to applied science experiments. Such systems enable the development of promising future technologies, such as laser-based particle accelerators.

ELI-ALPS laser system is employed in a wide range of experiments, such as generating coherent X-ray radiation through gas, electron acceleration and surface higher-order harmonic generation. The generation of isolated attosecond pulses for attosecond metrology is another important application. These kinds of experiments demand high stability of operation with high uptime, so the stability and precision of the whole system are one of researchers top priorities.

Due to the exceptionally large XUV/X-ray energy, this system opens the door to nonlinear XUV and X-ray science, as well as 4D imaging and industrial, biological, and medical applications.

To ensure reliability and cutting-edge parameters, the system has been built from scratch by employing industry-tested technologies and components. All design and manufacturing activities have been carried out in facilities in Vilnius. Thus, despite its complexity, the system ensures exceptional stability and reliability. SYLOS 3 delivers approximately 120 mJ pulses with a CEP (Carrier-Envelope Phase) stability of less than 250 mrad and pulse energy stability of less than 1%.

SYLOS series laser systems are outstanding outcome of close cooperation between researchers and enggineers. As result the Szeged facility stands out among institutes producing the highest intensity laser pulses in the world at a 1 kHz pulse repetition rate.

## SPECIFICATIONS

| Model | FF401k-F8-CEP | FF1201k-F8-CEP |
|---|---|---|
| **MAIN SPECIFICATIONS** [1] | | |
| Output energy | 40 mJ | 120 mJ |
| Peak pulse power | > 5 TW | > 15 TW |
| Pulse repetition rate | 1 kHz | 1 kHz |
| Wavelength [2] | 900 nm | 900 nm |
| Pulse duration | ≤ 8 fs (≤ 3 cycles) | ≤ 8 fs (≤ 3 cycles) |
| Pulse energy stability [3] | ≤ 1 % | ≤ 1 % |
| Long-term power drift [4] | ± 1.5 % | ± 1.5 % |
| CEP stability | ≤ 250 mrad | ≤ 250 mrad |
| Beam spatial profile | Super-Gaussian [5] | Super-Gaussian [5] |
| Beam diameter | ~ 50 mm | ~ 100 mm |
| Beam pointing stability [6] | ≤ 20 µrad | ≤ 20 µrad |
| Strehl ratio [7] | > 0.7 | > 0.7 |
| Temporal contrast [8] | | |
| APFC (within ± 50 ps) | $10^{10}$ : 1 | $10^{10}$ : 1 |
| Pre-pulse (≤ 50 ps) | $10^{10}$ : 1 | $10^{10}$ : 1 |
| Post-Pulse (>50 ps) | $10^{8}$ : 1 | $10^{8}$ : 1 |
| **PHYSICAL CHARACTERISTICS** [9] | | |
| Laser head size (W×L×H mm) | 9000 × 5000 × 1200 | 9000 × 9000 × 1200 |
| Umbilical length | up to 10 m | up to 5 m |

| Model | FF401k-F8-CEP | FF1201k-F8-CEP |
|---|---|---|
| **OPERATING REQUIREMENTS** [10] | | |
| Electrical power | 208, 380 or 400 V AC, three-phase, 50/60 Hz [11] | 208, 380 or 400 V AC, three-phase, 50/60 Hz [11] |
| Power consumption [12] | ≤ 40 kVA | ≤ 60 kVA |
| Water supply | ≤ 30 l/min, 2 Bar, max 15 °C | ≤ 40 l/min, 2 Bar, max 15 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements.

2) Central wavelength is calculated as the power-weighted mean frequency from measured spectrum in frequency domain.

3) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 30 s).

4) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

5) Super-Gaussian spatial mode of 6-11$^{th}$ order in near field.

6) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 30 s).

7) Strehl ratio of > 0.7 is achieved with deformable mirror option.

8) Pulse contrast is only limited by amplified parametric fluorescence (APFC) in the temporal range of ~90 ps which covers OPCPA pump pulse duration and is better than $10^6$:1. APFC contrast depends on OPCPA saturation level. Our OPCPA systems are ASE-free and pulse contrast value in nanosecond range is limited only by measurement device capabilities (third-order autocorrelator). There are no pre-pulses generated in the system and post-pulses are eliminated by using wedged transmission optics.

9) System sizes are preliminary and depend on customer lab layout and additional options purchased.

10) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

11) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

12) Required current rating can be calculated by dividing power rating by mains voltage. Power rating is given in apparent power (kVA) for systems with flash lamp power supplies and in real power (kW) for systems without flash lamp power supplies where reactive power is neglectable.


## OPTIONS

| Option | Description | Comment |
|---|---|---|
| -F8 | Short Pulse option reduces output pulse duration to ≤ 8 fs | Wavelength tunability not available with 'F8' option |
| -CEP | CEP stabilization to ≤ 250 mrad | Passive and active CEP stabilization |
| -DM | 'Deformable Mirror' option for Strehl ration improvement to > 0.7 | |
| -ps out | Additional narrow spectra ps output that is optically synchronized to main system output | Can be simultaneous and non-simultaneous to the main system output |

## PERFORMANCE

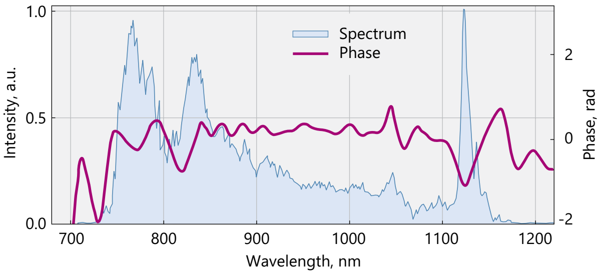


*Fig 1.* Typical output spectra and spectral phase of UltraFlux FF401k-F8-CEP-DM system

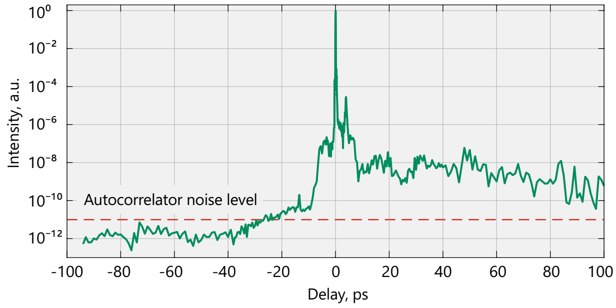


*Fig 2.* Typical temporal contrast of UltraFlux FF401k-F8-CEP-DM system

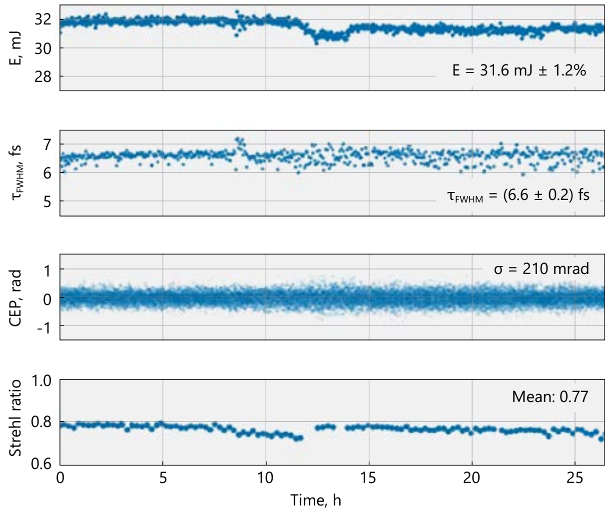


*Fig 3.* Typical long-term energy, pulse duration, CEP and Strehl ratio stability of UltraFlux FF401k-F8-CEP-DM system

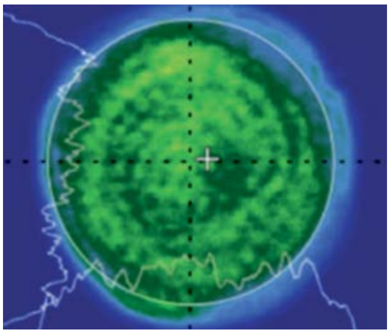

*Fig 4.* Typical UltraFlux FF401k-F8-CEP-DM near field beam profile


*Fig 5.* Typical external view of UltraFlux FF401k-F8-CEP-DM system (ELI-ALPS, SYLOS2A system)

## ORDERING INFORMATION

**UltraFlux FF(1)(2)-(3)**

Energy level:
40 → 50 mJ
100 → 100 mJ

Pulse repetition rate:
100 → 100 Hz
1k → 1 kHz

Additional options:
F8 → output pulse duration to ≤ 8 fs
CEP → CEP stabilization to ≤ 250 mrad
DM → Deformable Mirror' option for Strehl ration improvement to > 0.7
ps out → Additional ps output that is optically synchronized to main system output.

# High Energy Flash Lamp Pumped Picosecond Amplifiers

## PicoFlux HE SERIES


### APPLICATIONS

- *Time resolved spectroscopy*
- *SFG/SHG spectroscopy*
- *Nonlinear spectroscopy*
- *OPCPA pumping*
- *OPG/OPA pumping*
- *Remote laser sensing*
- *Satellite ranging*
- *Other spectroscopic and nonlinear optics applications...*

### FEATURES

- ***Flash lamp pumped picosecond amplifiers***
- *Pulse energies up to **2.2 J***
- ***20 – 300 ps** pulse duration*
- ***10 Hz** pulse repetition rate*
- *Diode pumped regenerative amplifier*
- *Internal or external seeding source*
- *Advanced beam shaping for high pulse energy*
- *Thermally induced birefringence compensated design*
- *Less than **10 ps RMS** jitter synchronization pulses for streak camera triggering*
- *Control through USB and LAN interfaces with supplied Windows control software (RS232 optional)*
- *Vacuum image relay system*
- *Optional temperature stabilized second, third and fourth harmonic generators*
- *Optional extremely precise synchronization to external RF signal with PLL option*
- *Optional Gaussian like spatial beam profile with Gaussian fit > 85% in near field*
- *Optional reduced pulse duration to 20 ps*

High energy PicoFlux series amplifiers are designed to produce high energy picosecond pulses at 1064 nm. High pulse energy, excellent pulse-to-pulse energy stability, superior beam quality makes these amplifiers well suited for applications like OPCPA pumping, non-linear optics and others.

### Regenerative amplifier / Power amplifier design

PicoFlux series amplifiers are designed to be seeded by external seeding source. Diode pumped regenerative amplifier ensures amplification of seed signal to stable mJ level pulse for amplification in linear amplifiers. Advanced beam shaping ensures smooth, without hot spots beam spatial profile at the laser output. Low light depolarization level allows high efficiency generation of up to 4th harmonic with optional build-in harmonic generators.
Alternatively EKSPLA can offer an internal seeder meeting customer's requirements.

### Build-in harmonic generators

Angle-tuned non-linear crystals harmonic generators mounted in temperature stabilized heaters are used for second, third and fourth harmonic generation. Harmonic separation system is designed to ensure high spectral purity of radiation and direct it to the output ports.

### Simple and convenient laser control

For customer convenience the amplifier can be controlled through USB and LAN interfaces (RS232 as optional). The amplifier can be controlled from personal computer with supplied software for Windows operating system.

## SPECIFICATIONS

| Model | P30010 | P60010 | P1k10 | P2k10 |
|---|---|---|---|---|
| **MAIN SPECIFICATIONS** [1] | | | | |
| Output energy | | | | |
| Fundamental | 300 mJ | 600 mJ | 1 000 mJ | 2 200 mJ [2) 3)] |
| SH output [4) 5)] | 200 mJ | 400 mJ | 650 mJ | 1 400 mJ |
| TH output [4] | 90 mJ | 180 mJ | 300 mJ | 660 mJ |
| FH output [4] | 30 mJ | 60 mJ | 100 mJ | 220 mJ |
| Pulse repetition rate | 10 Hz | 10 Hz | 10 Hz | 10 Hz |
| Pulse duration [6] | 90 ± 10 ps | 90 ± 10 ps | 90 ± 10 ps | 90 ± 10 ps |
| Pulse energy stability [7] | | | | |
| Fundamental | ≤ 0.6 % | ≤ 0.6 % | ≤ 0.6 % | ≤ 0.6 % |
| SH output [4] | ≤ 0.8 % | ≤ 0.8 % | ≤ 0.8 % | ≤ 0.8 % |
| TH output [4] | ≤ 2 % | ≤ 2 % | ≤ 2 % | ≤ 2 % |
| FH output [4] | ≤ 3 % | ≤ 3 % | ≤ 3 % | ≤ 3 % |
| Long-term power drift [8] | ± 2 % | ± 2 % | ± 2 % | ± 2 % |
| Beam spatial profile | Super-Gaussian [9] | Super-Gaussian [9] | Super-Gaussian [9] | Super-Gaussian [9] |
| Beam diameter [10] | 9 mm | ~11 mm | ~17 mm | ~23 mm |
| Beam pointing stability [11] | ≤ 30 μrad | ≤ 30 μrad | ≤ 30 μrad | ≤ 30 μrad |
| Beam divergence | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad |
| Pre-pulse contrast [12] | > 200:1 | > 200:1 | > 200:1 | > 200:1 |
| Optical pulse jitter [13] | | | | |
| Trig out | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps |
| Pre-Trig out | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps |
| With –PLL option | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps |
| Polarization | Linear | Linear | Linear | Linear |
| **PHYSICAL CHARACTERISTICS** [14] | | | | |
| Laser head size (W×L×H mm) | 600 × 1200 × 300 | 600 × 1500 × 300 | 600 × 1800 × 300 | 900 × 1800 × 300 |
| Power supply size (W×L×H mm) | 553 × 600 × 650 | 553 × 600 × 830 | 553 × 600 × 1230 | 553 × 600 × 1230 |
| Umbilical length [15] | 2.5 m | 2.5 m | 2.5 m | 2.5 m |
| **OPERATING REQUIREMENTS** [16] | | | | |
| Electrical power | 200 – 240 V AC, single-phase, 47 – 63 Hz | 200 – 240 V AC, single-phase, 47 – 63 Hz | 208, 380 or 400 V AC, three-phase, 50/60 Hz [17] | 208, 380 or 400 V AC, three-phase, 50/60 Hz [17] |
| Power consumption [18] | ≤ 2 kVA | ≤ 2.5 kVA | ≤ 4.5 kVA | ≤ 7 kVA |
| Water supply | ≤ 3 l/min, 2 Bar, max 20 °C | ≤ 6 l/min, 2 Bar, max 20 °C | ≤ 12 l/min, 2 Bar, max 20 °C | ≤ 14 l/min, 2 Bar, max 15 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements. All parameters measured at 1064 nm if not stated otherwise.

2) 2 200 mJ energy is achieved with Super-Gaussian spatial beam profile of 11$^{th}$ or higher order (with steep edges). If lower order Super-Gaussian is required maximum pulse energy will be limited to 2 000 mJ.

3) 2 500 mJ output energy is available upon request with longer pulse duration.

4) Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous.

5) Second harmonic specification is valid when only SH option is ordered. If TH/FH options are orders second harmonic efficiency is reduced to ~50 %.

6) Standard pulse duration is 90 ps. Other pulse durations can be ordered within range of 20 ps – 300 ps. Shortening the pulse duration below 90 ps will reduce the output energy proportionally.

7) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

8) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

9) Super-Gaussian spatial mode of 6-11$^{th}$ order in near field.

# PicoFlux HE series

10) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

11) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

12) 1000:1 contrast available upon request.

13) Optical pulse jitter with respect to electrical outputs:
– Trig out > 3.5 V @ 50 Ω
– Pre-Trig out > 1 V @ 50 Ω
– PLL option > 1 V @ 50 Ω

14) System sizes are preliminary and depend on customer lab layout and additional options purchased.

15) Longer umbilical with up to 10 m available upon request.

16) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

17) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

18) Required current rating can be calculated by dividing power rating by mains voltage. Power rating is given in apparent power (kVA) for systems with flash lamp power supplies and in real power (kW) for systems without flash lamp power supplies where reactive power is neglectable.

## OPTIONS

| Option | Description | Comment |
|---|---|---|
| -P20...300 | Custom pulse duration between 20 ps and 300 ps | Available with internal and external seeder. Shortening the pulse duration below 90 ps will reduce the output energy proportionally |
| -G | Gaussian like spatial beam profile | Reduces the output energy of fundamental by ~80 % |
| -FS | External seeder input via motorized spectral broadening stage | Requires > 1.5 nJ per pulse @ 800 nm, ≤ 100 fs |
| -PLL | Phase Lock Loop option for precise lock to external RF signal | Electrical to optical signal jitter ≤ 3 ps |
| -SH/TH/FH | Second, third and fourth harmonic outputs | Conversion efficiency from fundamental respectively ~50 %, ~30 % and ~10 %. Harmonic outputs not simultaneous with fundamental output |
| -AW | Water-to-Air cooling | Replaces or supplements Water-to-Water cooling unit. Heat dissipation equals total power consumption |

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm | Width W, mm | Depth D, mm |
|---|---|---|---|---|
| MR-9 | 9 U | 455.5 (519 1)) | 553 | 600 |
| MR-12 | 12 U | 589 (653 1)) | 553 | 600 |
| MR-16 | 16 U | 768 (832 1)) | 553 | 600 |
| MR-20 | 20 U | 889 (952 1)) | 553 | 600 |
| MR-25 | 25 U | 1167 (1231 1)) | 553 | 600 |

1) Full height with wheels.

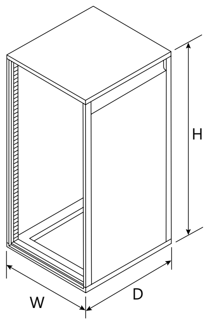


*Fig 1.* Typical PicoFlux laser system power supply dimensions (MR rack used depends on the laser model)

*Fig 2.* Integrated multi-channel high energy PicoFlux pump lasers into OPCPA

## PERFORMANCE

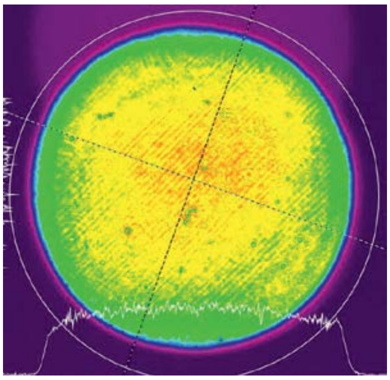

*Fig 3.* Typical High Energy PicoFlux amplifier system near field beam profile at 1064 nm (imaged from laser output)

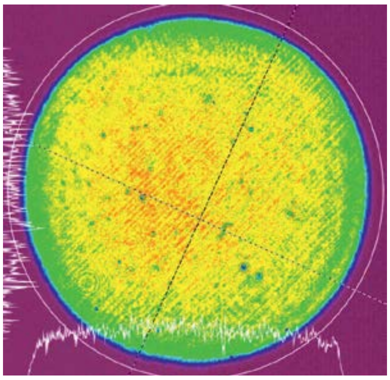

*Fig 4.* Typical High Energy PicoFlux amplifier system near field beam profile at 532 nm (imaged from SH crystal)

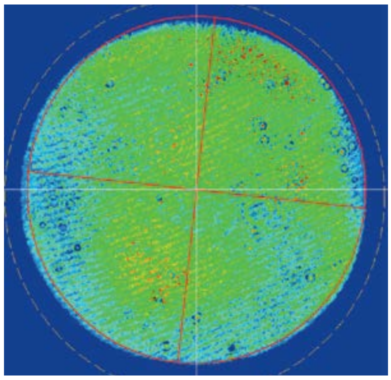

*Fig 5.* Typical High Energy PicoFlux amplifier system near field beam profile at 355 nm (imaged from TH crystal)

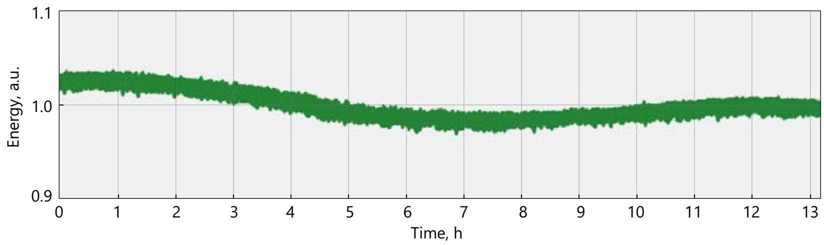


*Fig 6.* Typical long-term energy stability of High Energy PicoFlux system

## OUTLINE DRAWINGS

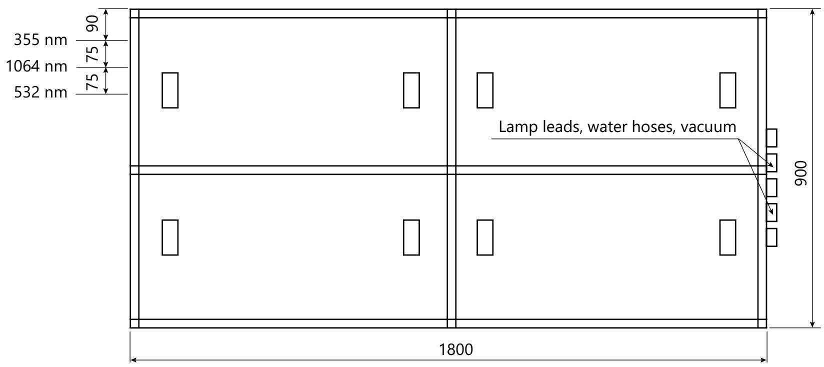


*Fig 7.* Typical PicoFlux P2k10 laser system external dimensions

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

**PicoFlux P(1)(2)-(3)**

Any additional options:
See 'Options' table

Energy level:
300 → 300 mJ
600 → 600 mJ
1k → 1000 mJ
2k → 2200 mJ

Pulse repetition rate:
SS → Single Shot
5 → 5 Hz
10 → 10 Hz

# High Repetition Rate Diode Pumped Picosecond Amplifiers

## PicoFlux HP SERIES


### APPLICATIONS

- *Time resolved spectroscopy*
- *SFG/SHG spectroscopy*
- *Nonlinear spectroscopy*
- *OPCPA pumping*
- *OPG/OPA pumping*
- *Remote laser sensing*
- *Satellite ranging*
- *Other spectroscopic and nonlinear optics applications...*

### FEATURES

- *Diode pumped picosecond amplifiers*
- *Pulse energies up to **150 mJ***
- ***20 – 300 ps** pulse duration*
- *High pulse energy up to **2 kHz** pulse repetition rate*
- *Diode pumped solid state design*
- *Advanced beam shaping for high pulse energy*
- *Internal or external seeding source*
- *Thermally induced birefringence compensated*
- *Low maintenance costs*
- *Less than **10 ps RMS** jitter synchronization pulses for streak camera triggering*
- *Control through USB and LAN interfaces with supplied Windows control software (RS232 optional)*
- *Vacuum image relay system*
- *Optional temperature stabilized second, third and fourth harmonic generators*
- *Optional extremely precise synchronization to external RF signal with PLL option*
- *Optional Gaussian like spatial beam profile with Gaussian fit > 85 % in near field*
- *Optional reduced pulse duration to 20 ps*

High repetition rate PicoFlux series amplifiers are designed to produce up to 150 mJ picosecond pulses at 1 kHz repetition rate (or 500 mJ at 100 Hz repetition rate). High pulse energy, excellent pulse-to-pulse energy stability, superior beam quality makes these amplifiers well suited for applications like OPCPA pumping, non-linear optics and others.

### Regenerative amplifier / Power amplifier design

PicoFlux series amplifiers are designed to be seeded by external seeding source. Diode pumped regenerative amplifier ensures amplification of seed signal to stable mJ level pulse for amplification in linear amplifiers. Advanced beam shaping ensures smooth, without hot spots beam spatial profile at the laser output. Low light depolarization level allows high efficiency generation of up to 4th harmonic with optional build-in harmonic generators. Alternatively EKSPLA can offer an internal seeder meeting customer's requirements.

### Build-in harmonic generators

Angle-tuned LBO and/or BBO crystals mounted in temperature stabilized heaters are used for second, third and fourth harmonic generation. Harmonic separation system is designed to ensure high spectral purity of radiation and direct it to the output ports.

### Simple and convenient laser control

For customer convenience the amplifier can be controlled through USB and LAN interfaces (RS232 as optional). The amplifier can be controlled from personal computer with supplied software for Windows operating system.


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REV. 260105

## SPECIFICATIONS

| Model | P500100 | P301k | P601k | P1301k |
|---|---|---|---|---|
| **MAIN SPECIFICATIONS** [1] | | | | |
| Output energy | | | | |
| Fundamental | 500 mJ | 30 mJ | 60 mJ | 130 mJ |
| SH output [2] [3] | 300 mJ | 20 mJ | 40 mJ | 85 mJ |
| TH output [2] | 200 mJ | 10 mJ | 20 mJ | 50 mJ |
| FH output [2] | 50 mJ | 3 mJ | 6 mJ | 15 mJ |
| Pulse repetition rate | 100 Hz | 1 kHz | 1 kHz | 1 kHz |
| Pulse duration [4] | 90 ± 10 ps | 90 ± 10 ps | 90 ± 10 ps | 90 ± 10 ps |
| Pulse energy stability [5] | | | | |
| Fundamental | ≤ 0.5 % | ≤ 0.5 % | ≤ 0.5 % | ≤ 0.5 % |
| SH output [2] | ≤ 0.8 % | ≤ 0.8 % | ≤ 0.8 % | ≤ 0.8 % |
| TH output [2] | ≤ 2 % | ≤ 2 % | ≤ 2 % | ≤ 2 % |
| FH output [2] | ≤ 3 % | ≤ 3 % | ≤ 3 % | ≤ 3 % |
| Long-term power drift [6] | ± 1.5 % | ± 1.5 % | ± 1.5 % | ± 1.5 % |
| Beam spatial profile | Super-Gaussian [7] | Super-Gaussian [7] | Super-Gaussian [7] | Super-Gaussian [7] |
| Beam diameter [8] | ~ 12 mm | ~ 5 mm | ~ 7 mm | ~ 7 mm |
| Beam pointing stability [9] | ≤ 20 µrad | ≤ 20 µrad | ≤ 20 µrad | ≤ 20 µrad |
| Beam divergence | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad |
| Pre-pulse contrast [10] | > 200:1 | > 200:1 | > 200:1 | > 200:1 |
| Optical pulse jitter [11] | | | | |
| Trig out | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps |
| Pre-Trig out | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps |
| With –PLL option | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps |
| Polarization | Linear | Linear | Linear | Linear |
| **PHYSICAL CHARACTERISTICS** [12] | | | | |
| Laser head size (W×L×H mm) | 1200 × 2400 × 300 | 600 × 1500 × 300 | 900 × 1500 × 300 | 900 × 1800 × 300 |
| Power supply size (W×L×H mm) | 553 × 600 × 832<br>377 × 1015 × 1080 | 553 × 600 × 830 | 553 × 600 × 1230 | 553 × 600 × 1230 |
| Umbilical length [13] | 2.5 m | 2.5 m | 2.5 m | 2.5 m |
| **OPERATING REQUIREMENTS** [14] | | | | |
| Electrical power | 208, 380 or 400 V AC, three-phase, 50/60 Hz [15] | 208, 380 or 400 V AC, three-phase, 50/60 Hz [15] | 208, 380 or 400 V AC, three-phase, 50/60 Hz [15] | 208, 380 or 400 V AC, three-phase, 50/60 Hz [15] |
| Power consumption [16] | ≤ 5 kW | ≤ 5 kW | ≤ 10 kW | ≤ 22 kW |
| Water supply | ≤ 8 l/min, 2 Bar, max 20 °C | ≤ 14 l/min, 2 Bar, max 20 °C | ≤ 25 l/min, 2 Bar, max 20 °C | ≤ 40 l/min, 2 Bar, max 15 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements. All parameters measured at 1064 nm if not stated otherwise.

2) Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous.

3) Second harmonic specification is valid when only SH option is ordered. If TH/FH options are orders second harmonic efficiency is reduced to ~50 %.

4) Standard pulse duration is 90 ps. Other pulse durations can be ordered within range of 20 – 300 ps. Shortening the pulse duration below 90 ps will reduce the output energy proportionally.

5) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

6) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

7) Super-Gaussian spatial mode of 6-11th order in near field.

8) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

# PicoFlux HP series

9) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

10) 1000:1 contrast available upon request.

11) Optical pulse jitter with respect to electrical outputs:
– Trig out > 3.5 V @ 50 Ω
– Pre-Trig out > 1 V @ 50 Ω
– PLL option > 1 V @ 50 Ω

12) System sizes are preliminary and depend on customer lab layout and additional options purchased.

13) Longer umbilical with up to 5 m available upon request.

14) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

15) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

16) Required current rating can be calculated by dividing power rating by mains voltage. Power rating is given in apparent power (kVA) for systems with flash lamp power supplies and in real power (kW) for systems without flash lamp power supplies where reactive power is neglectable.

## OPTIONS

| Option | Description | Comment |
|---|---|---|
| -P20...300 | Custom pulse duration between 20 ps and 300 ps | Available with internal and external seeder. Shortening the pulse duration below 90 ps will reduce the output energy proportionally |
| -50/100 | 50 Hz or 100 Hz pulse repetition rate | Energy can be increased ~4 times |
| -2k | 2 kHz pulse repetition rate | Reduces the output energy of fundamental by ~50 % |
| -G | Gaussian like spatial beam profile | Reduces the output energy of fundamental by ~80 % |
| -FS | External seeder input via motorized spectral broadening stage | Requires > 1.5 nJ per pulse @ 800 nm, 100 fs |
| -PLL | Phase Lock Loop option for precise lock to external RF signal | Electrical to optical signal jitter ≤ 3 ps |
| -SH/TH/FH | Second, third and fourth harmonic outputs | Conversion efficiency from fundamental respectively ~50 %, ~30 % and ~10 %. Harmonic outputs not simultaneous with fundamental output |
| -AW | Water-to-Air cooling | Replaces or supplements Water-to-Water cooling unit. Heat dissipation equals total power consumption |

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm | Width W, mm | Depth D, mm |
|---|---|---|---|---|
| MR-9 | 9 U | 455.5 (519 [1]) | 553 | 600 |
| MR-12 | 12 U | 589 (653 [1]) | 553 | 600 |
| MR-16 | 16 U | 768 (832 [1]) | 553 | 600 |
| MR-20 | 20 U | 889 (952 [1]) | 553 | 600 |
| MR-25 | 25 U | 1167 (1231 [1]) | 553 | 600 |

1) Full height with wheels.

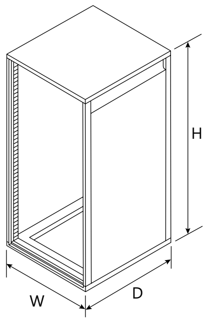


*Fig 1.* Typical PicoFlux laser system power supply dimensions (MR rack used depends on the laser model)


*Fig 2.* Typical external view of PicoFlux P1301k laser system (actual design might vary)

## PERFORMANCE

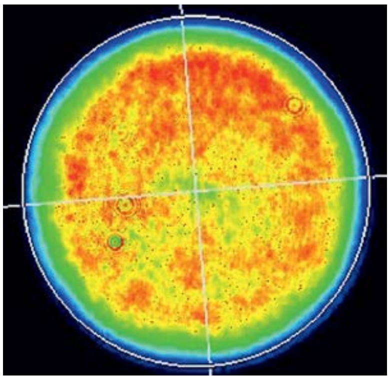

*Fig 3.* Typical High repetition rate PicoFlux amplifier system near field beam profile at 1064 nm (imaged from laser output)

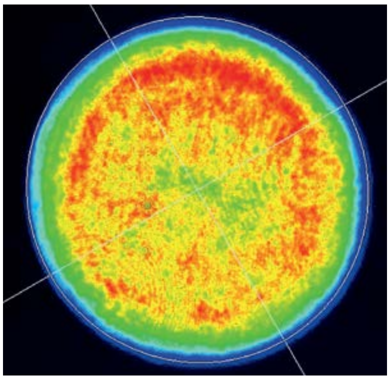

*Fig 4.* Typical High repetition rate PicoFlux amplifier system near field beam profile at 532 nm (imaged from SH crystal)

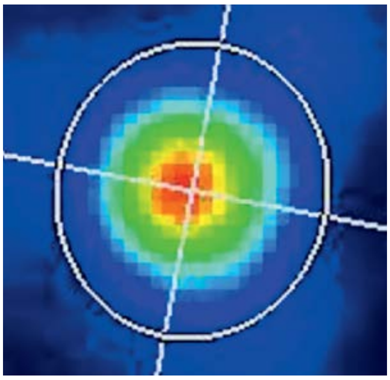

*Fig 5.* Typical High repetition rate PicoFlux amplifier system far field beam profile at 532 nm

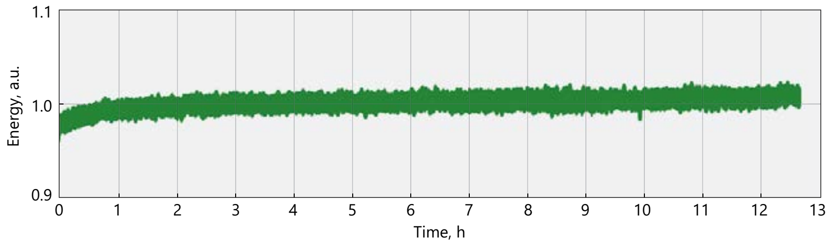


*Fig 6.* Typical long-term energy stability of High repetition rate PicoFlux amplifier system

## OUTLINE DRAWINGS

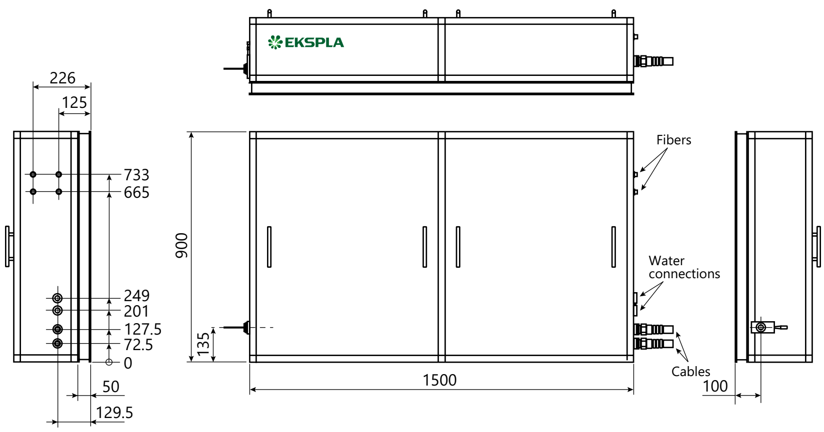


*Fig 7.* Typical PicoFlux P601k laser system external dimensions

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

**PicoFlux P(1)(2)-(3)**

Any additional options: See ‘Options’ table

Energy level:
100 → 10 mJ
30 → 30 mJ
60 → 60 mJ
130 → 130 mJ
500 → 500 mJ

Pulse repetition rate:
50 → 50 Hz
100 → 100 Hz
1k → 1 kHz
2k → 2 kHz

# Custom Picosecond Amplifiers

# PicoFlux Custom


## APPLICATIONS

- *Multi-stage OPCPA pumping*
- *Non-linear optics*
- *Other spectroscopic and nonlinear optics applications…*

## FEATURES

- *Flash lamp or diode pumped multi-channel PicoFlux systems*
- *Each of the channels can be **tailored according to pumping requirements***
- *High energy PicoFlux version with **variable burst***
- *Hybrid PicoFlux with fiber front-end and **Yb:YAG** amplifiers – **1 ps, 8 mJ** output at **10 kHz***
- ***1 – 300 ps** pulse duration*
- *From Single Shot to 10 kHz pulse repetition rate*
- *Internal or external seeding source*
- *Advanced beam shaping for high pulse energy*
- *Thermally induced birefringence compensated*
- *Low jitter synchronization pulses below 10 ps RMS jitter*
- *Vacuum image relay system*
- *Optional temperature stabilized second, third and fourth harmonic generators*

Multiple Channel PicoFlux series picosecond amplifiers were designed and manufactured for multiple stage OPCPA pumping. Systems can be specially tailored for customer's needs and have up to 8 pumping channels with different wavelength, energy, pulse duration, spatial and temporal profiles, adjustable delay, image translation to customers specified location and various other features. Short pulse duration, excellent pulse-to-pulse stability, superior beam quality makes PicoFlux series picosecond amplifiers well suited for other applications as well.

### Regenerative amplifier / Power amplifier design

PicoFlux series amplifiers are designed to be seeded by external seeding source. Diode pumped regenerative amplifier ensures amplification of seed signal to stable mJ level pulse for amplification in linear amplifiers. Advanced beam shaping ensures smooth, without hot spots beam spatial profile at the laser output. Low light depolarization level allows high efficiency generation of up to 4th harmonic with optional build-in harmonic generators.

Alternatively EKSPLA can offer an internal seeder meeting customer's requirements.

### Full-fiber front-end

Novel EKSPLA developed fiber front-end opens up new set of unique features for PicoFlux systems like dual wave seeder that also has burst formation functionality due to active fiber loop technology. The front-end also permits to offer powerful, ultrafast and higher frequency Ytterbium amplifiers for wider opportunities in OPCPA pumping and other scientific uses.

# PicoFlux Custom



## SPECIFICATIONS

| Model | P2k10-x4 | P1301k-x8 | P1k100-Burst | P810k-1030 |
|---|---|---|---|---|
| **MAIN SPECIFICATIONS** [1] | | | | |
| Output energy | | | | |
| Fundamental | 4 × 2 200 mJ [2] [3] | 8 × 130 mJ | 1.4 J Burst (4×300 mJ + 4×50 mJ) | 8 mJ @ 1030 nm |
| SH output [4] [5] | 4 × 1 400 mJ | 8 × 85 mJ | NA | NA |
| TH output [4] | 4 × 660 mJ | 8 × 50 mJ | NA | NA |
| FH output [4] | 4 × 220 mJ | 8 × 15 mJ | NA | NA |
| Pulse repetition rate | 10 Hz | 1 kHz | 100 Hz | 10 kHz |
| Pulse duration [6] | 90 ± 10 ps | 90 ± 10 ps | 90 ± 10 ps | 1 ± 0.2 ps |
| Pulse energy stability [7] | | | | |
| Fundamental | ≤ 0.6 % | ≤ 0.5 % | ≤ 1 % | ≤ 0.5 % |
| SH output [4] | ≤ 0.8 % | ≤ 0.8 % | NA | NA |
| TH output [4] | ≤ 2 % | ≤ 2 % | NA | NA |
| FH output [4] | ≤ 3 % | ≤ 3 % | NA | NA |
| Long-term power drift [8] | ± 2 % | ± 1.5 % | | |
| Beam spatial profile | Super-Gaussian [9] | Super-Gaussian [9] | Super-Gaussian and Gaussian [9] | Gaussian [9] |
| Beam diameter [10] | ~ 23 mm | ~ 7 mm | ~ 11 & 5 mm | ~ 6 mm |
| Beam pointing stability [11] | ≤ 30 µrad | ≤ 20 µrad | ≤ 20 µrad | ≤ 20 µrad |
| Beam divergence | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad |
| Pre-pulse contrast [12] | > 200:1 | > 200:1 | > 200:1 | > 200:1 |
| Optical pulse jitter [13] | | | | |
| Trig out | ≤ 100 ps | ≤ 100 ps | ≤ 100 ps | ≤ 50 ps |
| Pre-Trig out | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps | ≤ 50 ps |
| With –PLL option | ≤ 2 ps | ≤ 2 ps | ≤ 2 ps | NA |
| Polarization | Linear | Linear | Linear | Linear |
| **PHYSICAL CHARACTERISTICS** [14] | | | | |
| Laser head size (W×L×H mm) | 1500 × 3600 × 500, 2 pc. | 1500 × 3600 × 500, 4 pc. | 700 × 2000 × 300 | 900 × 1200 × 300 |
| Power supply size (W×L×H mm) | 553 × 600 × 1800, 4 pc. | 553 × 600 × 1800, 4 pc. | 553 × 952 × 600 | 553 × 952 × 600 |
| Umbilical length [15] | 5 m | 2.5 m | 2.5 m | 3 m |
| **OPERATING REQUIREMENTS** [16] | | | | |
| Electrical power | 208, 380 or 400 VAC, three-phase, 50/60 Hz [17] | 208, 380 or 400 VAC, three-phase, 50/60 Hz [17] | 208 – 240 VAC, single-phase, 50/60 Hz | 208 – 240 VAC, single-phase, 50/60 Hz |
| Power consumption [18] | ≤ 40 kVA | ≤ 60 kW | ≤ 5 kW | ≤ 3.5 kW |
| Water supply | ≤ 40 l/min, 2 Bar, max 15 °C | ≤ 40 l/min, 2 Bar, max 15 °C | ≤ 5 l/min, 2 Bar, max 15 °C | ≤ 15 l/min, 2 Bar, max 15 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements. All parameters measured at 1064 nm if not stated otherwise.

2) 2 200 mJ energy is achieved with Super-Gaussian spatial beam profile of 11th or higher order (with steep edges). If lower order Super-Gaussian is required maximum pulse energy will be limited to 2 000 mJ.

3) 2 500 mJ output energy is available upon request with longer pulse duration.

4) Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous.

5) Second harmonic specification is valid when only SH option is ordered. If TH/FH options are orders second harmonic efficiency is reduced to ~50 %.

6) Standard pulse duration is 90 ps. Other pulse durations can be ordered within range of 20 ps – 300 ps. Shortening the pulse duration below 90 ps will reduce the output energy proportionally.

7) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

# PicoFlux Custom

8) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

9) Super-Gaussian spatial mode of 6-11th order in near field.

10) Beam diameter is measured at signal output at 1/e2 level for Gaussian beams and FWHM level for Super-Gaussian beams.

11) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

12) 1000:1 contrast available upon request.

13) Optical pulse jitter with respect to electrical outputs:
– Trig out > 3.5 V @ 50 Ω
– Pre-Trig out > 1 V @ 50 Ω
– PLL option > 1 V @ 50 Ω

14) System sizes are preliminary and depend on customer lab layout and additional options purchased.

15) Longer umbilical with up to 10 m for flash lamp pumped and up to 5 m for diode pumped systems available upon request.

16) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

17) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

18) Required current rating can be calculated by dividing power rating by mains voltage. Power rating is given in apparent power (kVA) for systems with flash lamp power supplies and in real power (kW) for systems without flash lamp power supplies where reactive power is neglectable.

## OPTIONS

| Option | Description | Comment |
|---|---|---|
| -P20...300 | Custom pulse duration between 20 ps and 300 ps | Available with internal and external seeder. Shortening the pulse duration below 90 ps will reduce the output energy proportionally |
| -50/100 | 50 Hz or 100 Hz pulse repetition rate | Energy can be increased ~4 times compared to 1 kHz systems |
| -2k | 2 kHz pulse repetition rate | Reduces the output energy of fundamental by ~50 % |
| -G | Gaussian like spatial beam profile | Reduces the output energy of fundamental by ~80 % |
| -FS | External seeder input via motorized spectral broadening stage | Requires > 1.5 nJ per pulse @ 800 nm, 100 fs |
| -PLL | Phase Lock Loop option for precise lock to external RF signal | Electrical to optical signal jitter ≤ 3 ps |
| -SH/TH/FH | Second, third and fourth harmonic outputs | Conversion efficiency from fundamental respectively ~50 %, ~30 % and ~10 %. Harmonic outputs not simultaneous with fundamental output |
| -AW | Water-to-Air cooling | Replaces or supplements Water-to-Water cooling unit. Heat dissipation equals total power consumption |

## PERFORMANCE

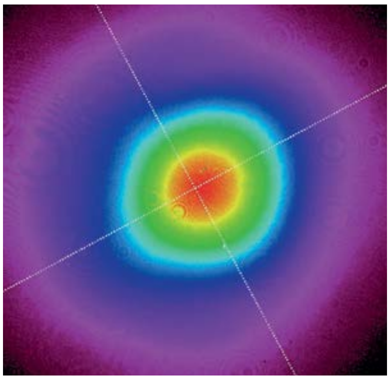

*Fig 1.* Typical PicoFlux Ytterbium system amplifier system near field beam profile at 1030 nm (imaged from laser output)

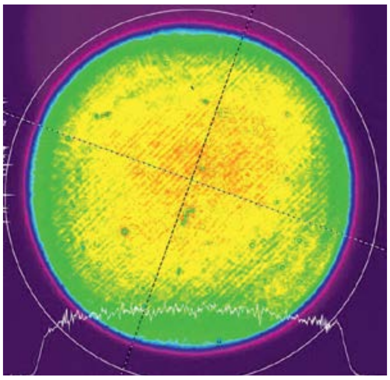

*Fig 2.* Typical High Energy PicoFlux amplifier system near field beam profile at 1064 nm (imaged from laser output)

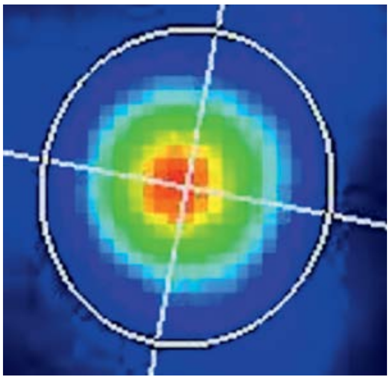

*Fig 3.* Typical High repetition rate PicoFlux amplifier system far field beam profile at 532 nm (imaged from SH crystal)

# PicoFlux Custom



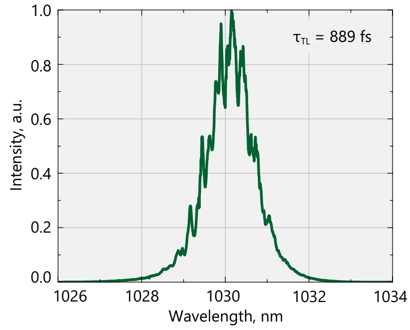


*Fig 4.* Typical output pulse spectrum of the PicoFlux Ytterbium system

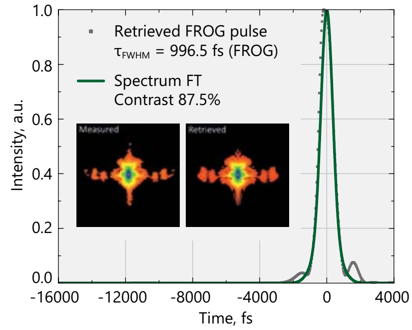


*Fig 5.* Typical pulse shape (FROG measurement) PicoFlux Ytterbium system

## STABILITY

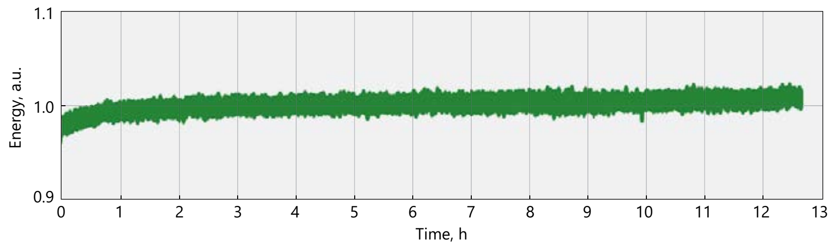


*Fig 6.* Typical long-term energy stability of High repetition rate PicoFlux system

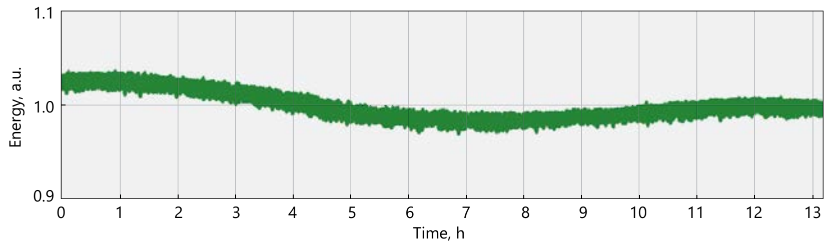


*Fig 7.* Typical long-term energy stability of High Energy PicoFlux system

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

**PicoFlux P(1)(2)-x(3)-(4)**

Energy level:
130 → 130 mJ
2k → 2200 mJ

Pulse repetition rate:
10 → 10 Hz
1k → 1 kHz

Number of channels:
x4 → four channels
x8 → eight channels

Any additional options:
See 'Options' table

# Single Mode (SLM) High Energy Q-switched Nd:YAG Lasers

## NanoFlux SLM SERIES


Typical external view of NanoFlux N2k10-SLM laser head (actual design might vary)

NanoFlux SLM series electro-optically Q-switched nanosecond Nd:YAG lasers deliver up to 10 J per pulse with excellent stability. These systems are an excellent choice for many applications, including OPO, OPCPA or dye laser pumping, holography, LIF spectroscopy, remote sensing, optics testing and other tasks.

The innovative, diode-pumped, self-seeded master oscillator design results in Single Longitudinal Mode (SLM) output without the use of external expensive narrow linewidth seed diodes and cavity-locking electronics. Unlike more common designs that use an unstable laser cavity, the stable master oscillator cavity produces a $TEM_{00}$ spatial mode output that results in excellent beam properties after the amplification stages. For tasks that require a smooth and as close as possible to the Gaussian beam profile, models with improved Gaussian fit are available.

NanoFlux series linear amplifiers are cost effective solution for high energy nanosecond systems. Advanced beam shaping ensures smooth, without hot spots beam spatial profile at the laser output. Low light depolarization level allows high efficiency generation of up to $4^{th}$ harmonic with optional build-in harmonic generators. The simple and field proven design ensures easy maintenance and reliable long-term operation of the NanoFlux SLM series laser.

Angle-tuned non-linear crystals harmonic generators mounted in temperature stabilized heaters are used for second, third and fourth harmonic generation. Harmonic separation system is designed to ensure high spectral purity of radiation and direct it to the output ports. Harmonic generators can be integrated into laser head or placed outside laser head into auxiliary harmonic generator module. Output wavelength switching is done manually. Motorized wavelength switching is available by request.

The low jitter of the optical pulse with respect to the Q-switch triggering pulse allows the reliable synchronization between the laser and external equipment.

System control is available through control pad, USB and LAN interfaces (RS232 as optional). The system can be controlled from personal computer with supplied software for Windows operating system.

### FEATURES

- *Up to **10 J** pulse energies*
- ***2 – 25 ns** pulse durations*
- ***10 Hz** pulse repetition rate*
- *Diode-pumped, self-seeded **Single Longitudinal Mode (SLM) master oscillator***
- *Stable master oscillator cavity producing **$TEM_{00}$** spatial mode output*
- ***Excellent** pulse energy **stability***
- ***Cost effective** flash lamp pumped power amplifier*
- ***Standard 2 ns** pulse duration (2 – 25 ns are optional)*
- *Temperature stabilized harmonics generator options*
- *Control through keypad, USB and LAN interfaces with supplied Windows control software (RS232 as optional)*

### APPLICATIONS

- *Material processing*
- *OPO, OPCPA, Ti:Sapphire, dye laser pumping*
- *Holography*
- *Nonlinear laser spectroscopy*
- *Optics testing*

# NanoFlux SLM series

## SPECIFICATIONS

| Model | N2k10-SLM | N5k10-SLM | N10k10-SLM |
|---|---|---|---|
| **MAIN SPECIFICATIONS [1)]** | | | |
| Output energy | | | |
| at 1064 nm | 2 000 mJ | 5 000 mJ | 10 000 mJ |
| at 532 nm [2) 3)] | 1 000 mJ | 2 500 mJ | 5 000 mJ |
| at 355 nm [2)] | 450 mJ | 1 300 mJ | 2 500 mJ |
| at 266 nm [2)] | 140 mJ | 750 mJ | 1 500 mJ |
| Pulse repetition rate | 10 Hz | 10 Hz | 10 Hz |
| Pulse duration [4)] | 2 ± 0.5 ns | 2 ± 0.5 ns | 2 ± 0.5 ns |
| Pulse energy stability [5)] | | | |
| at 1064 nm | ≤ 0.8 % | ≤ 0.8 % | ≤ 0.8 % |
| at 532 nm | ≤ 1.5 % | ≤ 1.5 % | ≤ 1.5 % |
| at 355 nm | ≤ 3 % | ≤ 3 % | ≤ 3 % |
| at 266 nm | ≤ 4 % | ≤ 4 % | ≤ 4 % |
| Long-term power drift [6)] | ± 2 % | ± 2 % | ± 2 % |
| Beam spatial profile [7)] | Super-Gaussian | Super-Gaussian | Super-Gaussian |
| $M^2$ [8)] | 4.4 | 6.6 | 9.2 |
| Beam diameter [9)] | ~12 mm | ~18 mm | ~25 mm |
| Beam pointing stability [10)] | ≤ 25 µrad | ≤ 25 µrad | ≤ 25 µrad |
| Beam divergence | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad |
| Optical pulse jitter [11)] | ≤ 0.2 ns | ≤ 0.2 ns | ≤ 0.2 ns |
| Linewidth | ≤ 0.01 $cm^{-1}$ (SLM) | ≤ 0.01 $cm^{-1}$ (SLM) | ≤ 0.01 $cm^{-1}$ (SLM) |
| Polarization | linear, >90 % | linear, >90 % | linear, >90 % |
| **PHYSICAL CHARACTERISTICS [12)]** | | | |
| Laser head size (W×L×H mm) | 455 × 1220 × 270 | 600 × 1500 × 300 | 700 × 2000 × 300 |
| Power supply size (W×L×H mm) | 550 × 600 × 1030 | 550 × 600 × 1030 – 2 units | 550 × 600 × 1650 – 2 units |
| Umbilical length [13)] | 5 m | 5 m | 5 m |
| **OPERATING REQUIREMENTS [14)]** | | | |
| Power requirements [15)] | 208, 380 or 400 V AC, three phase, 50/60 Hz | 208, 380 or 400 V AC, three phase, 50/60 Hz | 208, 380 or 400 V AC, three phase, 50/60 Hz |
| Power consumption [16)] | ≤ 5 kVA | ≤ 6 kVA | ≤ 8 kVA |
| Water supply [16)] | ≤ 5 l/min, 2 Bar, max 15 °C | ≤ 7 l/min, 2 Bar, max 15 °C | ≤ 10 l/min, 2 Bar, max 15 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements. All parameters measured at 1064 nm if not stated otherwise.

2) Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous.

3) Second harmonic is available with LBO crystal then the conversion efficiency is increased to 70%. If TH/FH options are ordered second harmonic efficiency is reduced to ~50 %.

4) Standard pulse duration is 2 ns. Other pulse durations can be ordered within range of 2 – 25 s. Output energy might differ depending on duration.

5) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

6) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

7) Super-Gaussian spatial mode of 6-11th order in near field.

8) The stated $M^2$ values are calculated using beam parameters. Actual measured value might differ.

9) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

10) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

11) Optical pulse jitter with respect to electrical outputs: Trig out > 3.5 V @ 50 Ω.

12) System sizes are preliminary and depend on customer lab layout and additional options purchased.

13) Longer umbilical with up to 10 m available upon request.


14) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

15) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

16) Power consumption and water supply requirements deviate depending on system configuration.

Femtosecond Lasers
Picosecond Lasers
Nanosecond Lasers

## OPTIONS

| Option | Description | Comment |
|---|---|---|
| - G | Provides a Gaussian-like beam profile | Reduces the output energy of fundamental by ~80 % |
| - AW | Water-air cooling option | Replaces or supplements Water-to-Water cooling unit. Heat dissipation equals total power consumption |
| - N2...N25 | Longer pulse duration option | In the range of 2 – 25 ns |

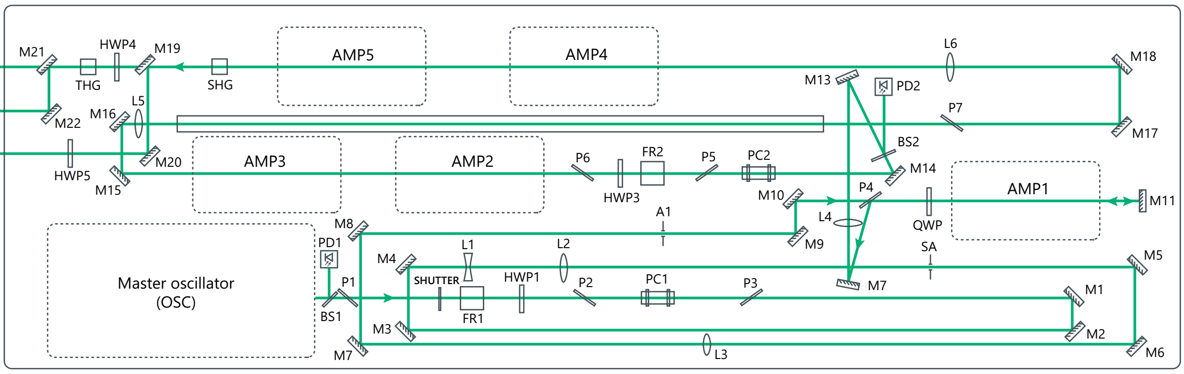


*Fig 1.* Principal optical layout of NanoFlux N10k10-SLM-SH-TH (actual layout might vary)

## PERFORMANCE

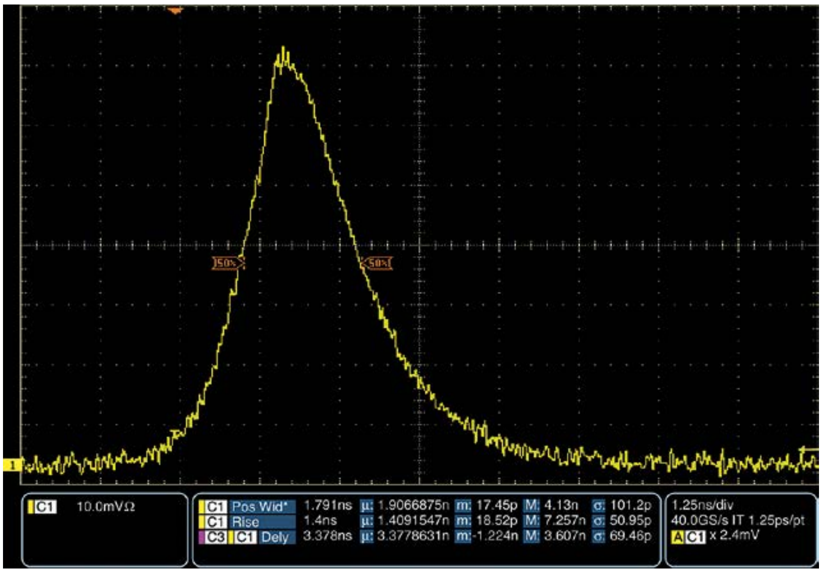


*Fig 2.* Typical temporal pulse shape of NanoFlux SLM system at 1064 nm

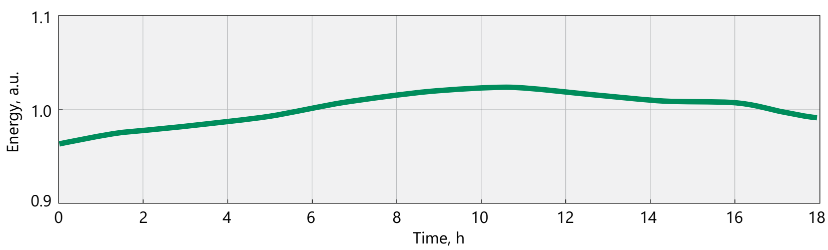


*Fig 3.* Typical long-term energy stability of High Energy NanoFlux system

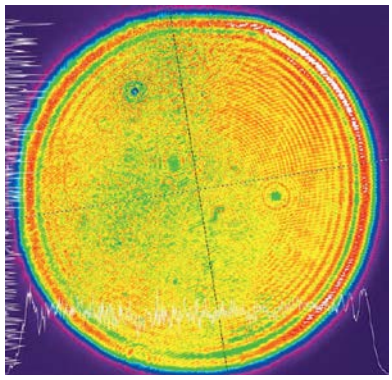

*Fig 4.* Typical beam profile of NanoFlux SLM laser system 50 cm from output at 1064 nm

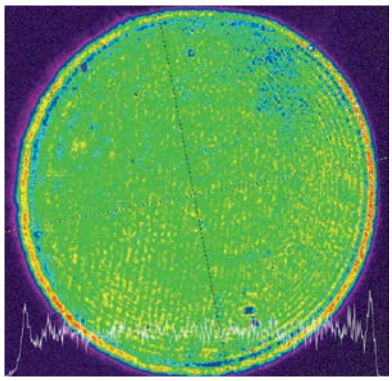

*Fig 5.* Typical beam profile of NanoFlux SLM laser system 30 cm from output at 532 nm

## OUTLINE DRAWINGS

*Fig 6.* Typical external view of NanoFlux N10k10-SLM (actual design might vary)

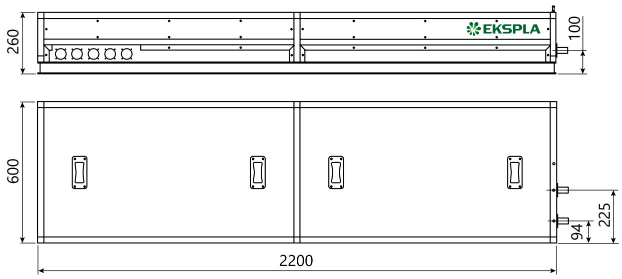


*Fig 7.* NanoFlux N10k10-SLM laser head outline drawing (actual dimensions might vary)

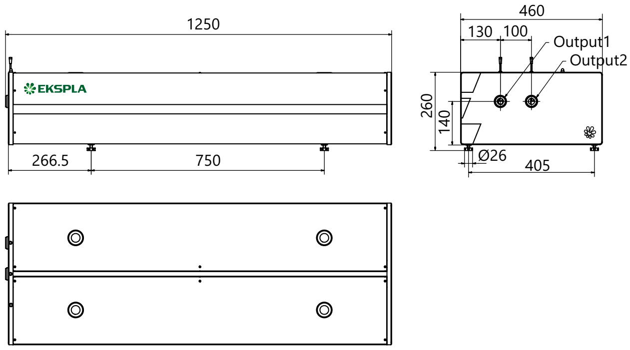


*Fig 8.* NanoFlux N2k10-SLM laser head outline drawing (actual dimensions might vary)

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm | Width W, mm | Depth D, mm |
|---|---|---|---|---|
| MR-9 | 9 U | 455.5 (519 [1]) | 553 | 600 |
| MR-12 | 12 U | 589 (653 [1]) | 553 | 600 |
| MR-16 | 16 U | 768 (832 [1]) | 553 | 600 |
| MR-20 | 20 U | 889 (952 [1]) | 553 | 600 |
| MR-25 | 25 U | 1167 (1231 [1]) | 553 | 600 |
| MR-34 | 34 U | 1640 (1709 [1]) | 553 | 600 |

[1] Full height with wheels.

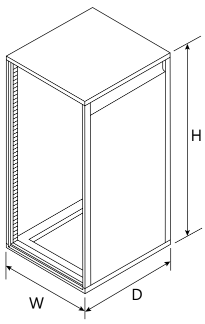


*Fig 9.* Typical NanoFlux SLM laser system power supply dimensions (MR rack used depends on the laser model)

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

**NanoFlux N(1)(2)-SLM-(3)**

Energy level:
2k → 2 J
5k → 5 J
10k → 10 J

Pulse repetition rate:
10 → 10 Hz

Any additional options:
See 'Options' table

# Multimode (MM) High Energy Q-switched Nd:YAG Lasers

# NanoFlux MM
## SERIES


Typical external view of NanoFlux N5k10 system (actual design might vary)

High energy NanoFlux MM series lasers are designed to produce high energy nanosecond pulses at 1064 nm. High pulse energy, excellent pulse-to-pulse energy stability, superior beam quality makes these systems well suited for applications like OPO or Ti: Sapphire pumping, material processing and plasma diagnostics and others.

NanoFlux MM series Q-switched oscillators are designed as extremely reliable and stable nanosecond seeding sources producing hundreds mJ pulses from a compact sized body. Simple access to critical compartments of the oscillator allows for easy maintenance. The higher $M^2$ version uses a pro-longed oscillator design that allows a much higher number of modes to oscillate which results in $M^2$ value up to 90. In this case the beam profile becomes very homogenous and flat which can be useful in a number of applications.

NanoFlux series linear amplifiers are cost effective solution for high energy nanosecond systems. Advanced beam shaping ensures smooth, without hot spots beam spatial profile at the laser output. Low light depolarization level allows high efficiency generation of up to 4th harmonic with optional build-in harmonic generators. The simple and field proven design ensures easy maintenance and reliable long-term operation of the NanoFlux MM series laser.

Angle-tuned non-linear crystals harmonic generators mounted in temperature stabilized heaters are used for second, third and fourth harmonic generation. Harmonic separation system is designed to ensure high spectral purity of radiation and direct it to the output ports. Harmonic generators can be integrated into laser head or placed outside laser head into auxiliary harmonic generator module. Output wavelength switching is done manually. Motorized wavelength switching is available by request.

Triggering of the laser is possible from built-in internal or external pulse generator. Pulses with TTL levels are required for external triggering. Laser pulses have less than 0.5 ns RMS jitter with respect to Q-switch triggering pulse in both cases.

System control is available through control pad, USB and LAN interfaces (RS232 as optional). The system can be controlled from personal computer with supplied software for Windows operating system.

## FEATURES

- *High energy nanosecond lasers*
- *Up to **10 J** pulse energies*
- ***5 ns** pulse duration*
- ***Up to 20 ns** pulse duration options available*
- ***10** or **20 Hz** pulse repetition rate*
- *Better than **0.5% RMS** pulse energy stability*
- *Up to 90 **$M^2$** version available*
- *High efficiency pump chambers and advanced beam shaping for maximum pulse energy extraction*
- *Relay imaging between amplifier stages for smooth beam profile at the laser output*
- *Thermally induced birefringence compensated*
- *Optional temperature stabilized second, third, fourth and fifth harmonic generators*
- *Low jitter internal/external synchronization*
- *Robust and stable laser head*
- *Control through keypad, USB and LAN interfaces with supplied Windows control software (RS232 as optional)*

## APPLICATIONS

- *OPO, Ti: Sapphire, dye laser pumping*
- *Material processing*
- *Plasma generation and diagnostics*
- *Nonlinear spectroscopy*
- *Remote sensing*

# NanoFlux MM series



## SPECIFICATIONS

| Model | N3k10 | N5k10 | N7k10 | N10k10 |
|---|---|---|---|---|
| **MAIN SPECIFICATIONS [1]** | | | | |
| Output energy | | | | |
| at 1064 nm | 3 000 mJ | 5 000 mJ | 7 000 mJ | 10 000 mJ |
| at 532 nm [2] [3] | 1 500 mJ | 2 500 mJ | 3 500 mJ | 5 000 mJ |
| at 355 nm [2] | 1 000 mJ | 1 300 mJ | 1 700 mJ | 2 000 mJ |
| at 266 nm [2] | 270 mJ | 400 mJ | 500 mJ | 700 mJ |
| Pulse repetition rate | 10 Hz | 10 Hz | 10 Hz | 10 Hz |
| Pulse duration [4] | 5 ± 1 ns | 5 ± 1 ns | 5 ± 1 ns | 5 ± 1 ns |
| Pulse energy stability [5] | | | | |
| at 1064 nm | ≤ 0.6 % | ≤ 0.6 % | ≤ 0.6 % | ≤ 0.6 % |
| at 532 nm | ≤ 1 % | ≤ 1 % | ≤ 1 % | ≤ 1 % |
| at 355 nm | ≤ 2 % | ≤ 2 % | ≤ 2 % | ≤ 2 % |
| at 266 nm | ≤ 3 % | ≤ 3 % | ≤ 3 % | ≤ 3 % |
| Long-term power drift [6] | ± 2 % | ± 2 % | ± 2 % | ± 2 % |
| Beam spatial profile [7] | Super-Gaussian | Super-Gaussian | Super-Gaussian | Super-Gaussian |
| $M^2$ [8] | ~5 | ~5 | ~5 | ~5 |
| Beam diameter [9] | ~18 mm | ~18 mm | ~25 mm | ~25 mm |
| Beam pointing stability [10] | ≤ 50 µrad | ≤ 50 µrad | ≤ 50 µrad | ≤ 50 µrad |
| Beam divergence | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad |
| Optical pulse jitter [11] | ≤ 0.5 ns | ≤ 0.5 ns | ≤ 0.5 ns | ≤ 0.5 ns |
| Linewidth | ≤ 1 $cm^{-1}$ | ≤ 1 $cm^{-1}$ | ≤ 1 $cm^{-1}$ | ≤ 1 $cm^{-1}$ |
| Polarization | Linear | Linear | Linear | Linear |
| **PHYSICAL CHARACTERISTICS [12]** | | | | |
| Laser head size (W×L×H mm) | 460 × 1250 × 260 | 500 × 1300 × 300 | 600 × 1800 × 300 | 700 × 2000 × 300 |
| Power supply size (W×L×H mm) | 550 × 600 × 1250 | 550 × 600 × 1250 | 550 × 600 × 1250 | 550 × 600 × 1640 |
| Umbilical length [13] | 5 m | 5 m | 5 m | 5 m |
| **OPERATING REQUIREMENTS [14]** | | | | |
| Power requirements [15] | 208, 380 or 400 V AC, three phase, 50/60 Hz | 208, 380 or 400 V AC, three phase, 50/60 Hz | 208, 380 or 400 V AC, three phase, 50/60 Hz | 208, 380 or 400 V AC, three phase, 50/60 Hz |
| Power consumption [16] | ≤ 5 kVA | ≤ 6 kVA | ≤ 7 kVA | ≤ 8 kVA |
| Water supply [16] | < 5 l/min, 2 Bar, max 15 °C | < 5 l/min, 2 Bar, max 15 °C | < 12 l/min, 2 Bar, max 15 °C | < 12 l/min, 2 Bar, max 15 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements. All parameters measured at 1064 nm if not stated otherwise.

2) Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous.

3) Second harmonic is available with LBO crystal then the conversion efficiency is increased to 70%. If TH/FH options are orders second harmonic efficiency is reduced to ~50 %.

4) Standard pulse duration is 5 ns. Other pulse durations can be ordered within range of 10 – 20 s. Output energy might differ depending on duration.

5) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

6) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

7) Super-Gaussian spatial mode of 6-11th order in near field.

8) $M^2$ value of ~5 is standard. Versions with $M^2$ in the range of 20 – 90 can be ordered.

9) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

10) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

11) Optical pulse jitter with respect to electrical outputs: Trig out > 3.5 V @ 50 Ω.

12) System sizes are preliminary and depend on customer lab layout and additional options purchased.

13) Longer umbilical with up to 10 m available upon request.


14) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

15) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

16) Power consumption and water supply requirements deviate depending on system configuration.

# NanoFlux MM series



## OPTIONS

| Option | Description | Comment |
|---|---|---|
| - G | Provides a Gaussian-like beam profile | Pulse energies are typically lower in comparison to standard version by 80 % |
| - M20...90 | Provides a flat, smooth beam profile, without hot spots and diffraction rings in the near and medium field | $M^2$ > 20 or $M^2$ > 90 |
| - RLI | Optional Relay Imaging for smooth beam profile | |
| - AW | Water-air cooling option | Replaces or supplements Water-to-Water cooling unit. Heat dissipation equals total power consumption |
| - N10...N20 | 10 – 20 ns pulse duration | |

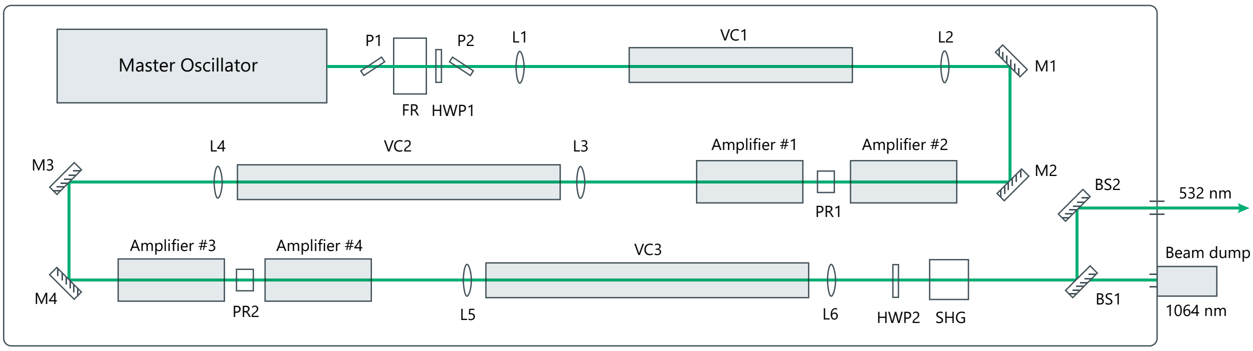


*Fig 1.* Principal optical layout of NanoFlux N10k10-SH (actual layout might vary)

## PERFORMANCE

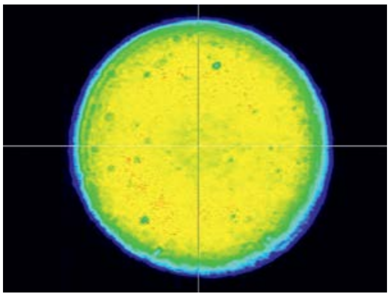

*Fig 2.* Typical beam profile of NanoFlux MM laser system at 1064 nm (imaged from amplifier exit)

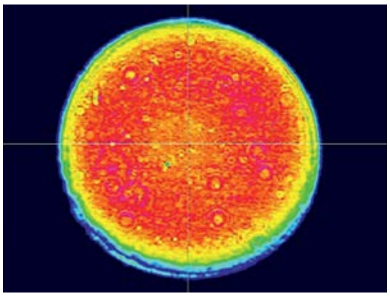

*Fig 3.* Typical beam profile of NanoFlux MM laser system at 532 nm (imaged from SH crystal)

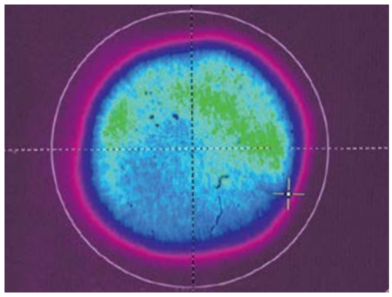

*Fig 4.* Typical beam profile of high $M^2$ version of NanoFlux MM laser system at 532 nm (imaged from SH crystal)

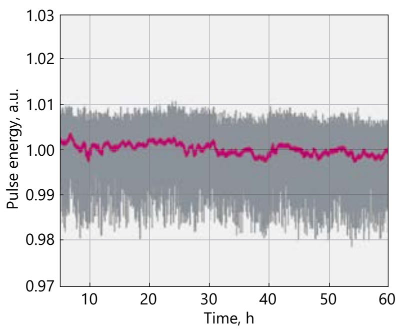


*Fig 5.* Typical long-term energy stability of High Energy NanoFlux system


*Fig 6.* Typical external view of NanoFlux N10k10-MM (actual design might vary)

## OUTLINE DRAWINGS

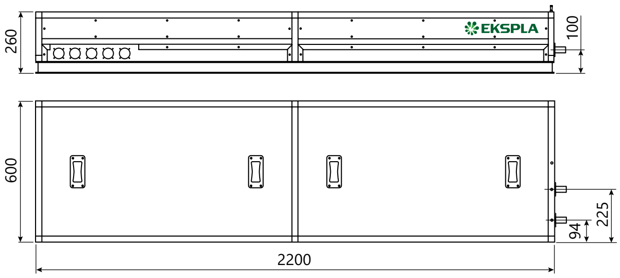


*Fig 7.* NanoFlux N7k10 or NanoFlux N10k10 laser head outline drawing (actual dimensions might vary)

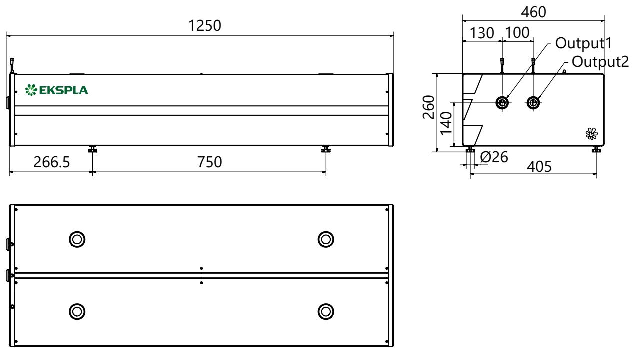


*Fig 8.* NanoFlux N3k10 or NanoFlux N5k10 laser head outline drawing (actual dimensions might vary)

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm | Width W, mm | Depth D, mm |
|---|---|---|---|---|
| MR-9 | 9 U | 455.5 (519 [1]) | 553 | 600 |
| MR-12 | 12 U | 589 (653 [1]) | 553 | 600 |
| MR-16 | 16 U | 768 (832 [1]) | 553 | 600 |
| MR-20 | 20 U | 889 (952 [1]) | 553 | 600 |
| MR-25 | 25 U | 1167 (1231 [1]) | 553 | 600 |
| MR-34 | 34 U | 1640 (1709 [1]) | 553 | 600 |

[1] Full height with wheels.

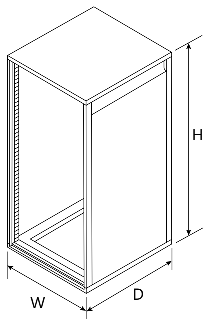


*Fig 9.* Typical NanoFlux laser system power supply dimensions (MR rack used depends on the laser model)

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

**NanoFlux N(1)(2)-(3)**

Energy level:
2k → 2 J
5k → 5 J
7k → 7 J
10k → 10 J

Pulse repetition rate:
SS → Single Shot
10 → 10 Hz

Any additional options:
See 'Options' table

# High Power Diode Pumped Nanosecond Amplifier Systems

## NanoFlux HP
SERIES

Typical external view of NanoFlux DPSS series laser system (actual design might vary)

NanoFlux series electro-optically Q-switched nanosecond Nd:YAG amplifier systems deliver high energy pulses at high repetition rates.

A diode-pumped Q-switched nanosecond laser, based on industry-tested technology is used as a master oscillator of the system. It produces high-intensity, high-brightness pulses and is well suited for further amplification in linear amplifiers for high-energy Super-Gaussian output pulses. Employing electro-optical cavity dumping, the master oscillator can produce pulses which are as short as several ns with uniform beam profile and low divergence.

Alternatively customers own seed source can be implemented as master oscillator and amplified to required energy level for further amplification in main power amplifiers.

Power amplifiers are a chain of low-maintenance diode-pumped single and double pass amplifiers where pulses are amplified up to the required energy. During amplification, spatial beam shaping is employed in order to get a Super-Gaussian beam shape at the output.

Angle-tuned non-linear crystals harmonic generators mounted in temperature stabilized heaters are used for second and third harmonic generation. Harmonic separation system is designed to ensure high spectral purity of radiation and direct it to the output ports.

System control is available through control pad, USB and LAN interfaces (RS232 as optional). The system can be controlled from personal computer with supplied software for Windows operating system.

To tailor the laser for specific applications or requirements, various customization possibilities are available such as industrial grade, portable laser housing with integrated power supplies and cooling units; customer's seed integration; multi-channel outputs; burst amplification and various other.

### FEATURES

- *Up to **5 J at 1064 nm** output pulse energy*
- *Up to **1 kHz** repetition rate*
- ***Multi-channel** version **2 J** per channel at 1064 nm*
- *Pulse durations **from 2 ns to 500 ns***
- *Spatial Super-Gaussian beam profile*
- *Low maintenance cost and long diode lifetime*
- *Variable pulse duration and temporal pulse shape control (AWG) option available*
- *Various customization possibilities to tailor for specific application*
- *High efficiency diode pumping chambers*
- *Small laser head footprint and OEM integration upon request*
- *Internal system diagnostics*
- *Thermally induced birefringence compensation for high pulse repetition rates*
- *Integrated vacuum system for image translation for smooth Super-Gaussian beam profile*
- ***Burst** version available*
- *Optional thermally stabilized second and third harmonics generators*
- *Optional industrial grade, portable laser housing with integrated power supplies and cooling units*

### APPLICATIONS

- *Thomson Scattering*
- *Multi-stage OPCPA pumping*
- *Non-linear optics*
- *Ti:S pumping*

## SPECIFICATIONS

| Model | N400100 | N5k100 | N2001k | N2k100-Burst |
|---|---|---|---|---|
| **MAIN SPECIFICATIONS [1]** | | | | |
| Output energy | | | | |
| at 1064 nm | 400 mJ | 5 000 mJ | 200 mJ | 2 000 mJ |
| at 532 nm [2] [3] | 260 mJ | 3 000 mJ | 130 mJ | 1 300 mJ |
| at 355 nm [2] | 120 mJ | Inquire | 60 mJ | 600 mJ |
| Pulse repetition rate | 100 Hz | 100 Hz | 1 kHz | 100 Hz |
| Pulse duration [4] | 5 ± 1 ns | 5 ± 1 ns | 5 ± 1 ns | Adjustable bursts |
| Pulse energy stability [5] | | | | |
| at 1064 nm | ≤ 0.5 % | ≤ 0.5 % | ≤ 0.5 % | ≤ 2 % |
| at 532 nm | ≤ 0.8 % | ≤ 0.8 % | ≤ 0.8 % | ≤ 4 % |
| at 355 nm | ≤ 2 % | ≤ 2 % | ≤ 2 % | |
| Long-term power drift [6] | ± 2 % | ± 2 % | ± 2 % | ± 2 % |
| Beam spatial profile | Super-Gaussian [7] | Super-Gaussian [7] | Super-Gaussian [7] | Super-Gaussian [7] |
| Beam diameter [8] | 7 mm | 15 mm | 7 mm | 12 mm |
| Beam pointing stability [9] | ≤ 30 µrad | ≤ 30 µrad | ≤ 30 µrad | ≤ 30 µrad |
| Beam divergence | ≤ 0.7 mrad | ≤ 0.5 mrad | ≤ 0.7 mrad | ≤ 0.5 mrad |
| Optical pulse jitter [10] | ≤ 0.2 ns | ≤ 0.2 ns | ≤ 0.2 ns | ≤ 0.2 ns |
| Polarization | Linear | Linear | Linear | Linear |
| **PHYSICAL CHARACTERISTICS [11]** | | | | |
| Laser head size (W×L×H mm) | 600×1200×300 | 900×2000×300 | 600×1200×300 | 900×1800×300 |
| Power supply size (W×L×H mm) | 553×600×830 | 553×600×1230 | 553×600×830 | 553×600×1800 |
| Umbilical length [12] | 2.5 m | 2.5 m | 2.5 m | 2.5 m |
| **OPERATING REQUIREMENTS [13]** | | | | |
| Power requirements [14] | 208, 380 or 400 V AC, three phases, 50/60 Hz | | | |
| Power consumption [15] | ≤ 6 kW | ≤ 20 kW | ≤ 10 kW | ≤ 10 kW |
| Water supply [15] | ≤ 8 l/min, 2 Bar, max 20 °C | ≤ 20 l/min, 2 Bar, max 20 °C | ≤ 12 l/min, 2 Bar, max 20 °C | ≤ 12 l/min, 2 Bar, max 20 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements. All parameters measured at 1064 nm if not stated otherwise.

2) Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous.

3) Second harmonic specification is valid when only SH option is ordered. If TH/FH options are orders second harmonic efficiency is reduced to ~50 %.

4) Standard pulse duration is 5 ns. Other pulse durations can be ordered within range of 0.2 – 500 ns. Output energy might differ depending on duration.

5) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s). Energy stability in burst mode heavily depends on temporal burst shape.

6) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

7) Super-Gaussian spatial mode of 6-11th order in near field.

8) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

9) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

10) Optical pulse jitter with respect to electrical outputs: Trig out > 3.5 V @ 50 Ω.

11) System sizes are preliminary and depend on customer lab layout and additional options purchased.

12) Longer umbilical with up to 5 m available upon request.

13) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.


14) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

15) Power consumption and water supply requirements deviate depending on system configuration.

## OPTIONS

| Option | Description | Comment |
|---|---|---|
| - AWG | Arbitrary waveform generator | Temporal pulse shape control in 1 – 50 ns range by 125 ps step |
| - AW | Water-air cooling option | Replaces or supplements Water-to-Water cooling unit. Heat dissipation equals total power consumption |
| - External vacuum supply | External vacuum pump and tubing | |
| - Multiple channel option | Multiple outputs of same or different wavelength/energy | Up to 8 channels |
| - G | Gaussian like spatial beam profile | Reduces the output energy of fundamental by ~80 % |

## PERFORMANCE

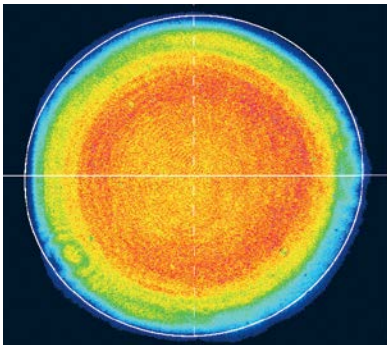

*Fig 1.* Typical NanoFlux DPSS system near field beam profile at 1064 nm

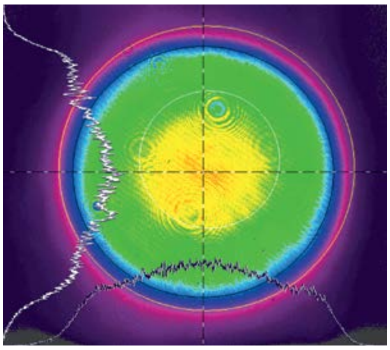

*Fig 2.* Typical NanoFlux DPSS system near field beam profile at 532 nm

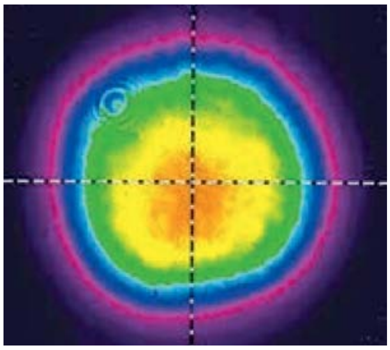

*Fig 3.* Typical NanoFlux DPSS system near field beam profile with Gaussian beam profile option purchased

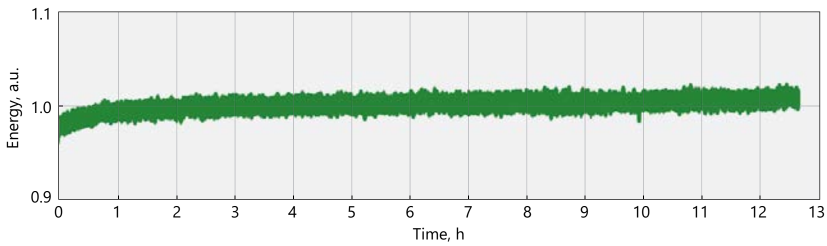


*Fig 4.* Typical long-term energy stability of High Power NanoFlux DPSS system

## OUTLINE DRAWINGS

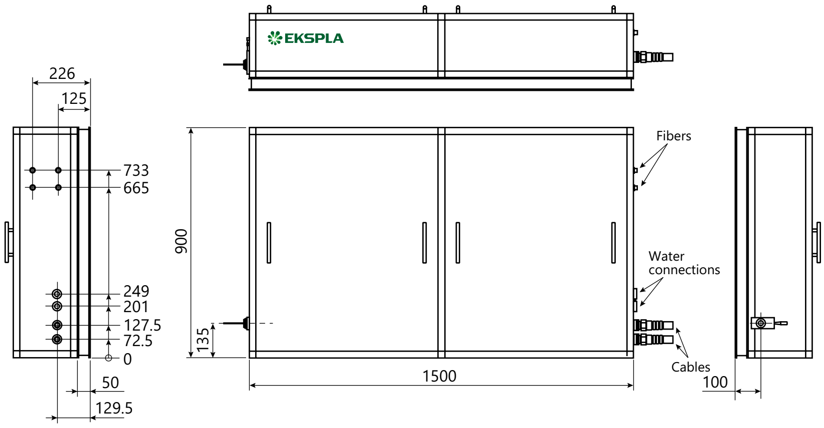


*Fig 5.* An example of NanoFlux DPSS system external dimensions

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm | Width W, mm | Depth D, mm |
|---|---|---|---|---|
| MR-9 | 9 U | 455.5 (519 [1]) | 553 | 600 |
| MR-12 | 12 U | 589 (653 [1]) | 553 | 600 |
| MR-16 | 16 U | 768 (832 [1]) | 553 | 600 |
| MR-20 | 20 U | 889 (952 [1]) | 553 | 600 |
| MR-25 | 25 U | 1167 (1231 [1]) | 553 | 600 |

[1] Full height with wheels.

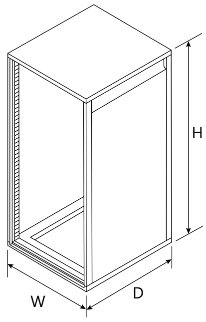


*Fig 6.* Typical NanoFlux laser system power supply dimensions (MR rack used depends on the laser model)

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

NanoFlux N(1)(2)-(3)

Energy level:
200 → 200 mJ
200 → 200 mJ
2k → 2000 mJ
5k → 5000 mJ

Pulse repetition rate:
SS → Single Shot
100 → 100 Hz
1k → 1000 Hz

Any additional options:
See 'Options' table

# Temporally Shaped (AWG) High Energy Nd:YAG Lasers

## NanoFlux AWG SERIES


Typical external view of NanoFlux N5k10-AWG-SH laser head

The main laser feature is the ability to shape output pulses temporally which is accomplished by an electro-optical modulator driven by programmable arbitrary waveform generator (AWG).

The front end of NanoFlux AWG laser system is comprised of a single-mode CW laser which is amplified in a fiber amplifier in the next step. Later on, AWG driven modulator transmits pulses of required temporal shape and duration which are further amplified diode pumped regenerative amplifier or all-in-fiber amplifier in order to reach energies sufficient to amplify in single-pass diode and flash lamp pumped amplifiers. Pulse shaping resolution is 125 ps, while maximum pulse length is 500 ns.

NanoFlux series linear amplifiers are convenient solution for high energy nanosecond systems where pulses are amplified in a chain of flash lamp pumped amplification units up to required energy. During amplification spatial beam shaping is used in order to get a flat top shaped beam profile without hot spots at the system output.

Angle-tuned non-linear crystals harmonic generators mounted in temperature stabilized heaters are used for second, third and fourth harmonic generation. Harmonic separation system is designed to ensure high spectral purity of radiation and direct it to the output ports.

### FEATURES

- *High energy nanosecond lasers*
- *Temporally shaped pulses*
- *Up to **10 J** pulse energies*
- ***10 Hz** pulse repetition rate*
- *Arbitrary waveform generator for pulse shaping*
- ***0.15 – 500 ns** adjustable pulse duration*
- ***Excellent** pulse energy **stability***
- ***Cost effective** flash lamp pumped power amplifier*
- *Optional temperature stabilized harmonics options*
- ***Super-Gaussian** beam profile*

### APPLICATIONS

- *OPCPA pumping*
- *Front end for power amplifiers*
- *Ti:Sapphire pumping*
- *Laser peening – material hardening by laser-induced shock wave*
- *Plasma and shock physics*

# NanoFlux AWG series



## SPECIFICATIONS

| Model | N2k10-AWG | N5k10-AWG | N10k10-AWG |
|---|---|---|---|
| **MAIN SPECIFICATIONS** [1] | | | |
| Output energy [2] | | | |
| at 1064 nm | 1 500 mJ | 5 000 mJ | 10 000 mJ (2 × 5 000 mJ) [3] |
| at 532 nm [4] [5] | 1 000 mJ | 3 000 mJ | 6 000 mJ |
| at 355 nm [4] | Inquire | Inquire | Inquire |
| Pulse repetition rate | 10 Hz | 10 Hz | 10 Hz |
| Pulse duration [6] | 0.15 – 20 ns | 0.15 – 20 ns | 0.15 – 20 ns |
| Pulse energy stability [7] | | | |
| at 1064 nm | ≤ 0.5 % | ≤ 0.5 % | ≤ 0.5 % |
| at 532 nm | ≤ 1 % | ≤ 1 % | ≤ 1 % |
| Long-term power drift [8] | ± 2 % | ± 2 % | ± 2 % |
| Beam spatial profile [9] | Super-Gaussian | Super-Gaussian | Super-Gaussian |
| Beam diameter [10] | ~11 mm | ~25 mm | ~25 mm |
| Beam pointing stability [11] | ≤ 50 µrad | ≤ 50 µrad | ≤ 50 µrad |
| Beam divergence | ≤ 0.5 mrad | ≤ 0.5 mrad | ≤ 0.5 mrad |
| Optical pulse jitter [12] | < 50 ps | < 50 ps | < 50 ps |
| Linewidth | Single-mode | Single-mode | Single-mode |
| Polarization | Linear, > 90 % | Linear, > 90 % | Linear |
| **PHYSICAL CHARACTERISTICS** [13] | | | |
| Laser head size (W×L×H mm) | 750 × 1350 × 300 | 700 × 2100 × 300 | 1000 × 2100 × 300 |
| Power supply size (W×L×H mm) | 550 × 600 × 840 – 1 unit<br>550 × 600 × 670 – 1 unit | 550 × 600 × 1220 - 2 units | 550 × 600 × 1220 – 2 units<br>550 × 600 × 670 – 1 unit |
| Umbilical length [14] | 5 m | 5 m | 5 m |
| **OPERATING REQUIREMENTS** [15] | | | |
| Power requirements [16] | 208, 380 or 400 V AC, three phases, 50/60 Hz | 208, 380 or 400 V AC, three phases, 50/60 Hz | 208, 380 or 400 V AC, three phases, 50/60 Hz |
| Power consumption [17] | ≤ 6 kVA | ≤ 9 kVA | ≤ 13 kVA |
| Water supply [17] | ≤ 5 l/min, 2 Bar, max 15 °C | ≤ 8 l/min, 2 Bar, max 15 °C | ≤ 12 l/min, 2 Bar, max 15 °C |
| Operating ambient temperature | 22 ± 2 °C | 22 ± 2 °C | 22 ± 2 °C |
| Storage ambient temperature | 15 – 35 °C | 15 – 35 °C | 15 – 35 °C |
| Relative humidity (non-condensing) | ≤ 80 % | ≤ 80 % | ≤ 80 % |
| Cleanness of the room | ISO Class 7 | ISO Class 7 | ISO Class 7 |

1) Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements. All parameters measured at 1064 nm if not stated otherwise.

2) The output energies are measured at 5 ns, rectangular pulse at time domain, FWHM.

3) The 10 J energy output is combined of two 5 J channels with vertical and horizontal polarizations.

4) Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous.

5) Second harmonic is available with LBO crystal then the conversion efficiency is increased to 70%. If TH/FH options are orders second harmonic efficiency is reduced to ~50 %.

6) Variable pulse duration in steps of 125 ps. Standard pulse duration adjustability is between 1-20 ns. Shorter or longer pulse durations are optional. Pulse shaping is possible in the range of 1 – 500 ns.

7) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

8) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

9) Super-Gaussian spatial mode of 6-11th order in near field.

10) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

11) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

12) Optical pulse jitter with respect to electrical outputs: Trig out > 3.5 V @ 50 Ω.

13) System sizes are preliminary and depend on customer lab layout and additional options purchased.

14) Longer umbilical with up to 10 m available upon request.

15) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.

16) Voltage fluctuations allowed are +10 % / -15 % from nominal value.


17) Power consumption and water supply requirements deviate depending on system configuration.

Femtosecond Lasers
Picosecond Lasers
Nanosecond Lasers

## OPTIONS

| Option | Description | Comment |
|---|---|---|
| - G | Provides a Gaussian-like beam profile | Pulse energies are typically lower in comparison to standard version by 80% |
| - AW | Water-air cooling unit or chiller | |
| - N20...N500 | Extended AWG pulse durations | Output energies (especially for SHG output) are specified for one pulse duration with square temporal pulse shape |

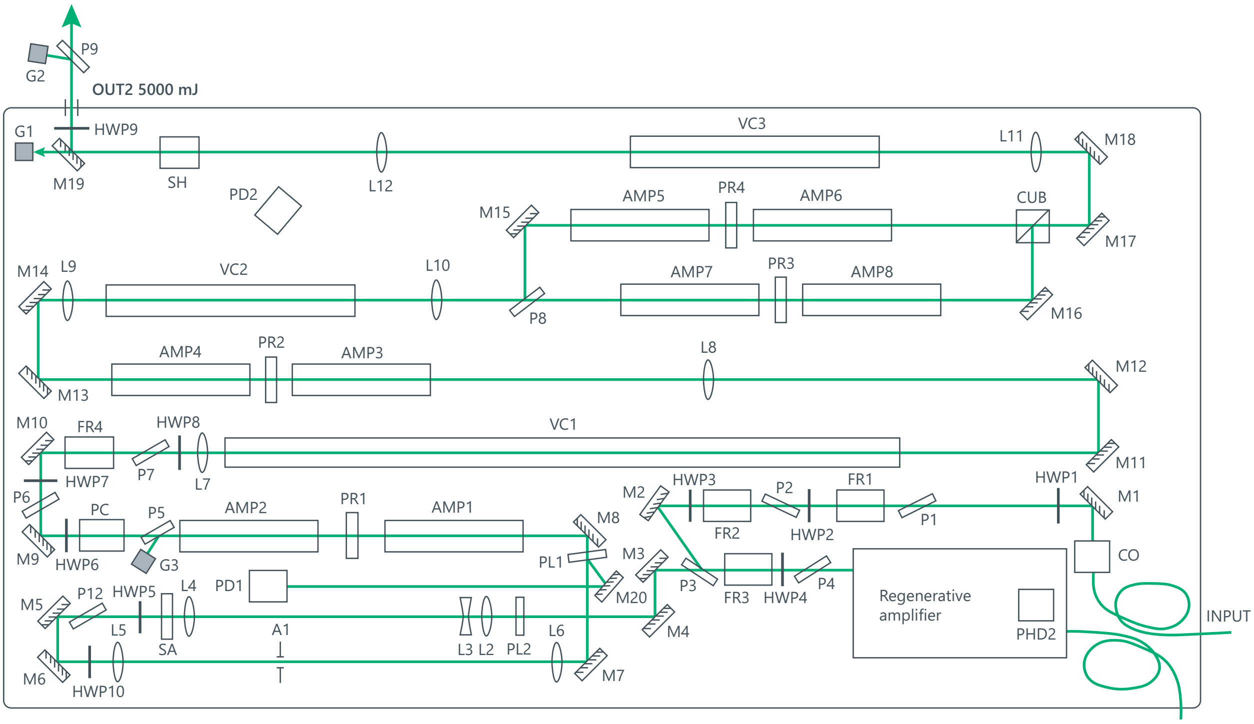


*Fig 1.* Principal optical layout of NanoFlux N10k10-AWG-SH (actual layout might vary)

## PERFORMANCE

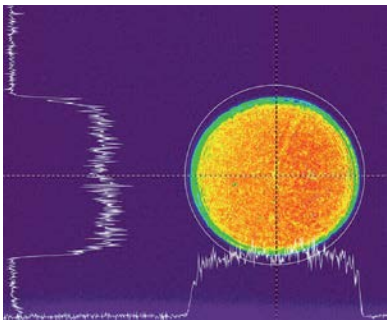

*Fig 2.* Typical beam profile of NanoFlux AWG laser system at 532 nm (imaged from SH crystal plane)

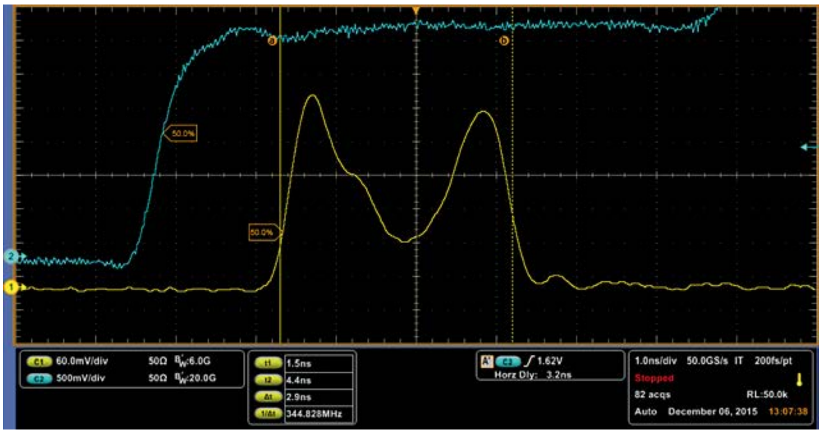

*Fig 3.* Temporally M shaped pulse (yelow line)

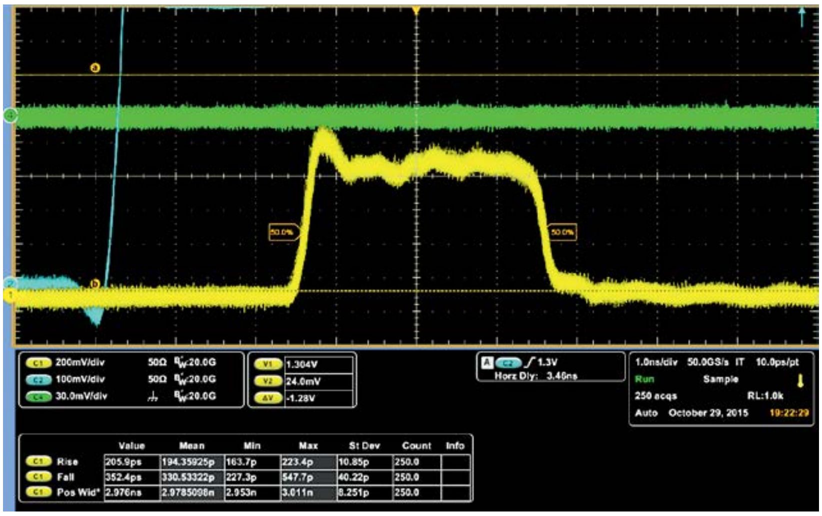

*Fig 4.* Temporally square shaped pulse (yelow line)

## OUTLINE DRAWINGS

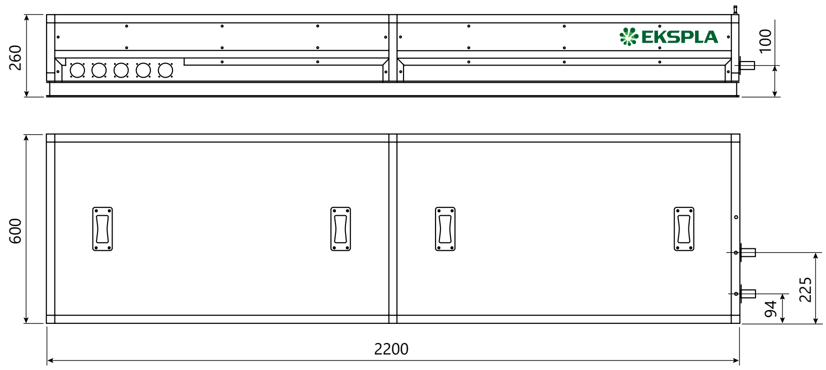


*Fig 5.* NanoFlux N10k10-AWG laser head outline drawing (actual dimensions might vary)

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm | Width W, mm | Depth D, mm |
|---|---|---|---|---|
| MR-9 | 9 U | 455.5 (519 [1]) | 553 | 600 |
| MR-12 | 12 U | 589 (653 [1]) | 553 | 600 |
| MR-16 | 16 U | 768 (832 [1]) | 553 | 600 |
| MR-20 | 20 U | 889 (952 [1]) | 553 | 600 |
| MR-25 | 25 U | 1167 (1231 [1]) | 553 | 600 |
| MR-34 | 34 U | 1640 (1709 [1]) | 553 | 600 |

[1] Full height with wheels.

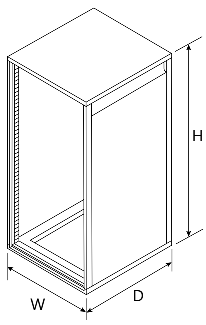


*Fig 6.* Typical NanoFlux AWG laser system power supply dimensions (MR rack used depends on the laser model)

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer that 1 hour then laser (system) needs warm up for a few hours before switching on.

NanoFlux N(1)(2)-AWG-(3)

Energy level:
2k → 2 J
5k → 5 J
10k → 10 J

Pulse repetition rate:
SS → Single Shot
10 → 10 Hz

Any additional options:
See 'Options' table

# Ordering Information

| | |
|---|---|
| **Delivery** | Products are made and dispatched within agreed term. Shipping charges are object of agreement between EKSPLA and customer. |
| **Ordering** | Orders may be placed by mail, fax or e-mail.<br>All orders are object of General Sales Conditions, which can be found on **www.ekspla.com**.<br>Mail orders should be sent to:<br>EKSPLA, UAB<br>Savanoriu Av. 237<br>LT-02300 Vilnius<br>Lithuania<br>Phone: +370 5 264 96 29<br>E-mail: sales@ekspla.com<br>**Ask for quotation online at www.ekspla.com.** |
| **Certificate of Origin** | All items shown in this catalogue are of Lithuanian Origin (EU). Certificate of Origin is available under request. |
| **Warranty** | All products are guaranteed to be free from defects in material and workmanship.<br>The warranty period depends on the product and is object of agreement between EKSPLA and customer. Warranty period can be extended by separate agreement. EKSPLA does not assume liability for improper installation, labor or consequential damages. |
| **Specifations** | Due to the constant product improvements, EKSPLA reserves its right to change specifications without advance notice. |

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