Tunable, high-power deep UV to NIR source of femtosecond pulses utilizing various Yb-doped pump-laser architectures

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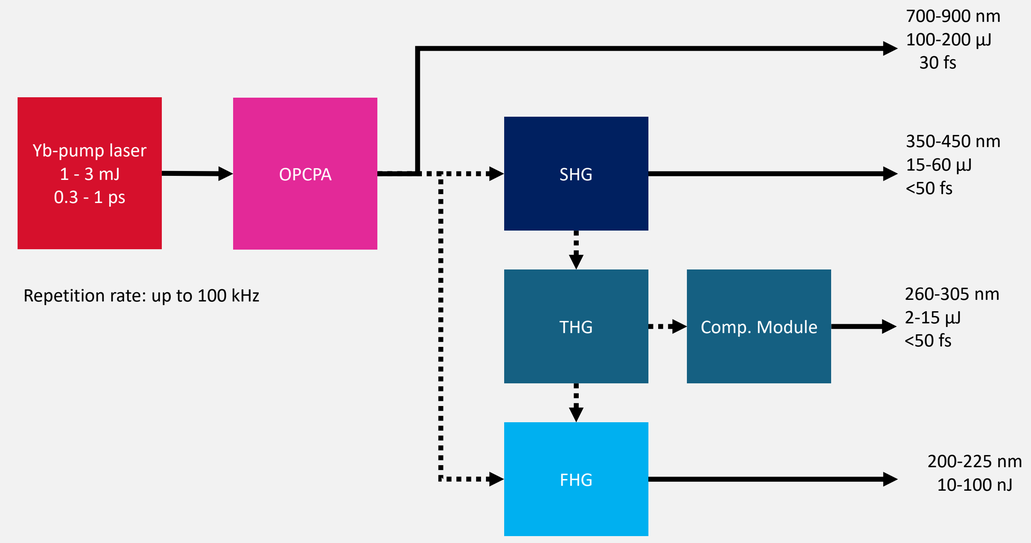
Motivation

Class 5 Photonics delivers ultrafast lasers for state-of-the-art applications, such as pump-probe-spectroscopy [1]/ -microscopy [2], attosecond science [3], particle acceleration [4], advanced micromachining and fabrication [5]. These laser systems require both high average power and high peak power. Many applications, in addition to the high average and peak power, require wavelength tunability, which can be provided by optical parametric chirped-pulse amplifier (OPCPA) technology. With a focus on customer demands, Class 5 Photonics has developed a tunable, high power OPCPA with sub-50 fs pulses ranging from the ultraviolet to the near-infrared spectral regions, which we call the *White Dwarf HE (OPCPA)*.

An important advantage of our OPCPA design is that it can be pump by various commercially available Yb-doped pump lasers at a fixed wavelength of 1030 nm, including the Amplitude *Tangor*, Trumpf Scientific *Dira* and the Light Conversion *Carbide*.

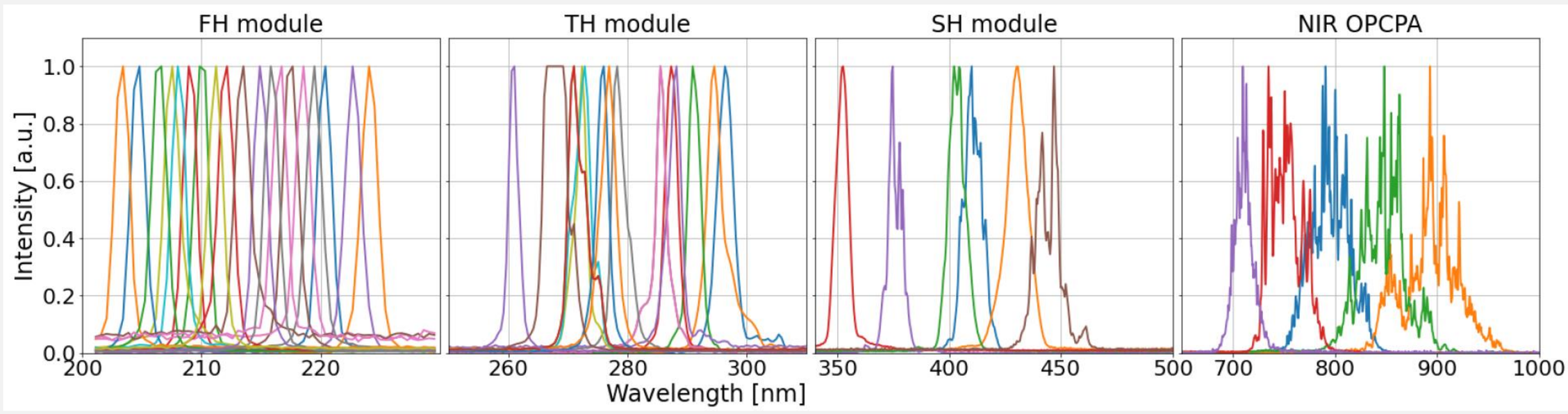
In this poster, we compare the system performances in terms of conversion efficiency, beam and pulse quality and show how the pump parameters translate into OPCPA output. Further details can be found in reference [6].

System Layout



Schematic layout of the tunable White Dwarf HE (OPCPA) with modules for second harmonic generation (SHG), third harmonic generation (THG) and fourth harmonic generation (THG) together with output parameters. This versatile laser system can be pumped by various commercially available Yb-pump lasers.

Performance: Tunability from UV to NIR

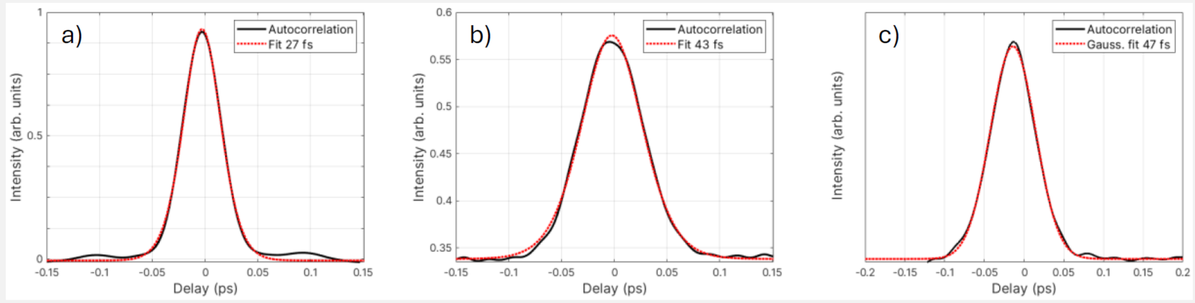


Normalized spectra of the Fourth-Harmonic (FH), Third-Harmonic (TH), Second-Harmonic (SH) generation modules and near infrared (NIR) fundamental outputs of the tunable OPCPA

Module	Parameter	Measurements White Dwarf HE OPCPA		
Pump laser	Model	Light conversion Carbide CB3-80W	Amplitude Tangor 300	Trumpf Scientific DIRA 500-10
	Pump power	20 W	150 W	30 W
	Repetition rate	10 kHz	100 kHz	10 kHz
	Pulse energy	2 mJ	1.2 mJ	3 mJ
	Pulse duration	350 fs	500 fs	800 fs
NIR OPCPA	Spectral tuning range	700 – 900 nm		
	Output power	> 1.5 W	> 12 W	> 2 W
	Pulse energy	> 150 µJ	> 120 µJ	> 230 µJ
	Power stability	< 0.5 % rms	< 0.3 % rms	< 2 % rms
	Pulse duration	< 30 fs	< 35 fs	< 35 fs
	M2 (x,y)	< 1.4 in both axes	< 1.5 in both axes	< 1.1 in both axes
SH Module	Spectral tuning range	350 – 450 nm		
	Output power	> 0.4 W	> 1.5 W	> 0.6 W
	Pulse energy	> 40 µJ	> 15 µJ	> 60 µJ
	Power stability	-	-	< 3 % rms
	Pulse duration	< 50 fs	< 50 fs	< 60 fs
TH Module	Spectral tuning range	235 – 300 nm		
	Output power	> 90 mW	> 200 mW	> 150 mW
	Pulse energy	> 9 µJ	> 2 µJ	> 15 µJ
	Power stability	-	-	< 3 % rms
	Pulse duration	< 100 fs (without prism comp.)	< 40 fs (with prism comp.)	< 100 fs (without prism comp.)
FH Module	Spectral tuning range	-	200-220 nm	-
	Output power	-	1 - 10 mW	-
	Pulse energy	-	10 - 100 nJ	-

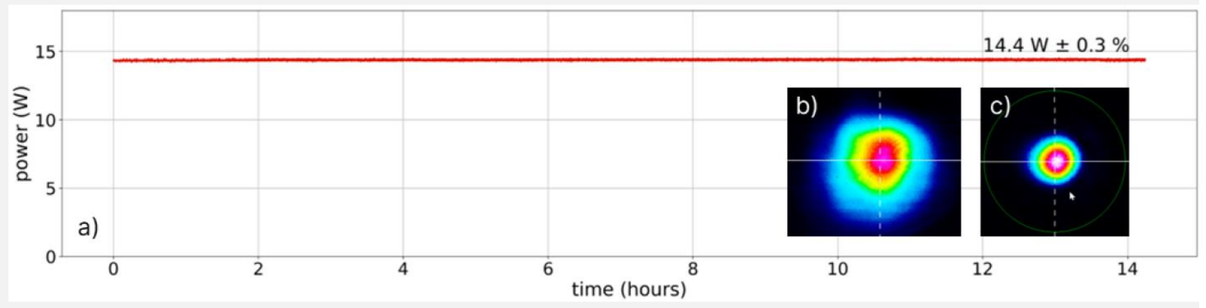
Summary of laser output parameters, pumped by three different commercially available Yb-pump lasers

Autocorrelation: (a) 800, (b) 400 and (c) 266 nm



Autocorrelation measurments of the outputs of the NIR OPCPA at 800 nm (a), SHG module at 400 nm (b), and THG module at 266 nm (c)

Beam Stability and Profile



Stability of the OPCPA output (a): Output 14.4 (±0.3%) W at 100 kHz repetition rate. Inserts show the near- (b) and far-field (c) beam profile of the OPCPA output

References

[1] F. Mahmood, et al, *Nature Phys.* **12,** 306-310 (2016); J. Oh, et al, *J. Phys. Chem C* **127,** 5004-5012 (2023)
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[5] C. Porter, et al, ”Soft x-ray: novel metrology for 3D profilometry and device pitch overlay”, *Proc. SPIE 12496, Metrology, Inspection, and Process Control XXXVII* (2023)
[6] V. Shumakova, et al, “Tunable, high-power deep UV to NIR source of femtosecond pulses utilizing various Yb-doped pump-laser architectures” *Proc. SPIE 13347* 133470J-1

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