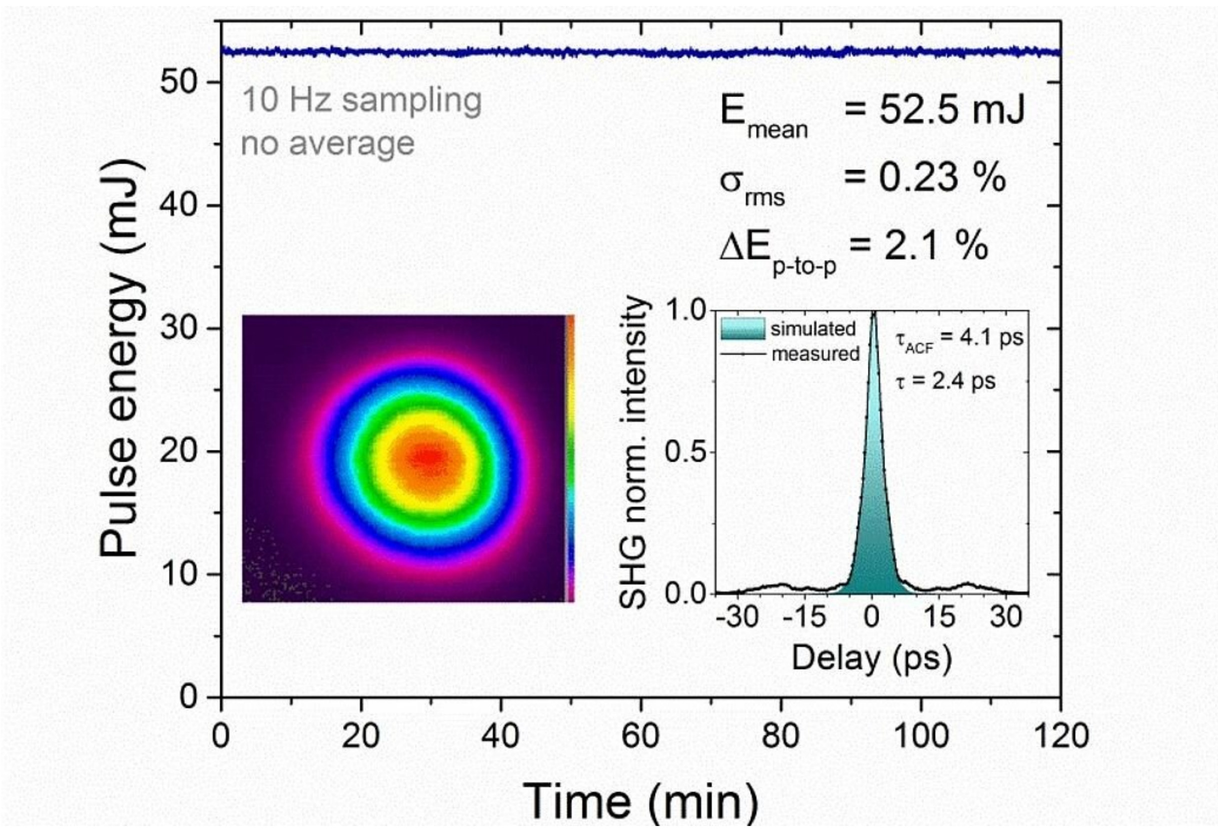
Highest peak power and excellent stability demonstrated in a laser

July 6 2020



Long term stability of the Ho:YLF chirped pulse amplifier at a 1 kHz repetition rate. The average pulse energy Emean=52.5 mJ was measured over a period of 120 minutes. The standard deviation has a value of σrms=0.23%, the pulse-to-pulse energy fluctuations are ΔEp-to-p=2.1%. Left inset: Beam profile (far-field intensity distribution). Right inset: Autocorrelation trace of the re-compressed 52.5 mJ pulses, measured and simulated. Credit: MBI

Power-scalable ultrafast laser sources in the midwave-infrared (MWIR) are a key element for basic research and applications in material processing and medicine. Optical amplifiers based on chirped pulse amplification (CPA) are used to generate high intensity pulses, a technique awarded with the Nobel Prize in physics in 2018. In the CPA scheme, a weak temporally stretched seed pulse is amplified to high energy in a laser amplifier and finally re-compressed resulting in an ultrashort pulse of very high intensity. Applying this concept a new system was developed at MBI delivering few-ps pulses at 2 µm wavelength with peak power beyond 10 GW (10 billion watt) at a 1 kHz repetition rate. The emitted pulses are characterized by excellent stability and brilliant beam quality. The results are reported in the latest issue of *Optics Letters*.

The main amplifiers of the 2-µm CPA system are based on Ho:YLF crystals and consist of a highly stable regenerative amplifier and two booster amplifiers. All of them are operated at room temperature and pumped by continuous-wave Tm:fiber lasers with a total power of 270 W. Starting from a 2-µm supercontinuum source the seed pulses are stretched and pre-amplified and subsequently fed into the Ho:YLF amplifier chain. The re-compressed pulse energy of the Ho:YLF CPA amounts to 52.5 mJ and reveals an excellent pulse-to-pulse stability of 93%. The recorded autocorrelation trace exhibits a FWHM of 4.1 ps. This corresponds to a duration of the main pulse of 2.4 ps (FWHM) with an estimated energy content of 85%, translating into 17 GW peak power. The latter and the pulse energy of >50 mJ represent the highest values ever achieved for few-ps pulses at 2 µm wavelength yet.

This source is currently being applied as pump in a system for the generation of few-cycle pulses around 5-µm with multi-millijoule energies. Applications in nonlinear optics, spectroscopy and materials processing are underway.

More information: Lorenz von Grafenstein et al, 205 μm chirped pulse amplification system at a 1 kHz repetition rate—24 ps pulses with 17 GW peak power, *Optics Letters* (2020). DOI: 10.1364/OL.395496

Provided by Forschungsverbund Berlin e.V. (FVB)