Proposal of ultra-high-power beams at the kilojoule iodine laser PALS

Ondřej Novák*[a], Martin Divoký[a], Petr Böhm[a], Martin Smrž[a], Radek Sedlář[a]
Hana Turčičová[b], Petr Straka[b]

[a]Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, CTU Prague, Břehová 2, 110 00 Prague 1, Czech Republic
[b]Department of Nonlinear Optics, Institute of Physics, AS of CR, Na Slovance 2, 182 21 Prague 8, Czech Republic

*novakon@fzu.cz

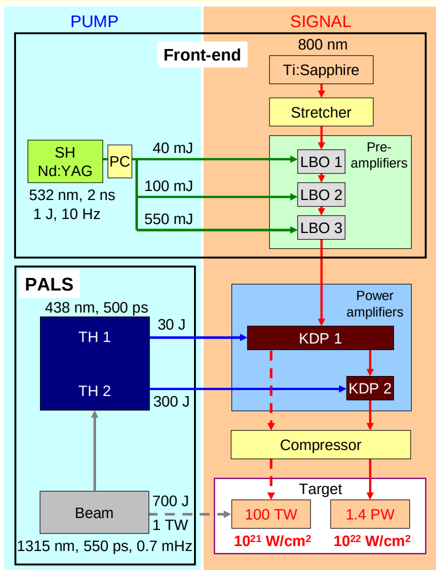
1. Introduction

The kilojoule terawatt 1.3-μm iodine laser PALS is occupied by users. To extend a scope of experiments, an implementation of an ultra-high-power beam was proposed. Chirped pulses of an 800-nm Ti:Sapphire oscillator could be parametrically amplified (OPCPA) by a third harmonic (TH) of the laser PALS [1]. Here, new 100 TW and 1 PW beams have been suggested in detail.

Fig. 1 The PALS laser hall

2. Model of parametric amplification and pulse compression

- Gaussian pump and signal pulses, a monochromatic pump
- Top-hat beams, equal pump and signal diameters in amplifiers, transmission between the amplifiers of 80%
- Front-end preamplifiers: a gain up to 1000, a repetition rate above 1 Hz
- Power amplifiers: a conversion efficiency around 20%
- Image relaying between the amplifiers by telescopes
- Pulse compressor with metal coated gratings with 1200 l/mm, transmission of 50%, and a full bandwidth of 200 nm
- Focus by f/2 optics, 2× diffraction limited



Stage	Energy [J] (100 TW)	Energy [J] (1 PW)	Diameter [mm] (100 TW)	Diameter [mm] (1 PW)	Pulsewidth FWHM
Ti:Sapphire	10 n				10 fs
Stretcher	1 n				310 ps
LBO 1	500 n		1		
LBO 2	200 μ		1.5		
LBO 3	30 m		3.5		
KDP 1	4.5		60		
KDP 2		65		190	
Compressor	2.1	30	60	200	20 fs
Target	2	28	0.004	0.004	20 fs

Fig. 2 Modeled scheme of the 100 TW and 1.4 PW beams at the PALS laboratory with a single front-end. The 100 TW beam can be supplemented by the kJ PALS beam (dashed, gray). The signal output parameters are in the table.

3. Results

Both the 100 TW and 1 PW beams having a single front-end are placed in the current PALS laser hall. A repetition rate of the ultra-high-power beams is a pulse per 25 minutes. A deformable mirror at the output of the pulse compressor improves a wavefront.

Front-end preamplifiers are pumped by a second harmonic (SH) of a Nd:YAG laser with a repetition rate of 10 Hz. A Pockels cell (PC) behind the Nd:YAG laser cuts the pump pulse to reduce parametric fluorescence.

100 TW beam with a rest of the kilojoule terawatt PALS beam (a wavelength of 1.3 μm or its harmonics) enables pump-probe experiments.

1.4 PW beam utilizes all energy of the PALS iodine laser in the power amplifiers.

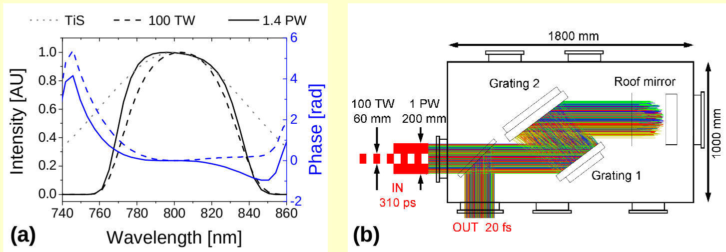


Fig. 3 (a) Relative phase, initial and amplified spectra of the 100 TW and 1 PW beams (bandwidths of 95 nm and ~60 nm FWHM, respectively). (b) A ray-traced cylindrical pulse compressor for both the 100 TW and 1 PW beams.

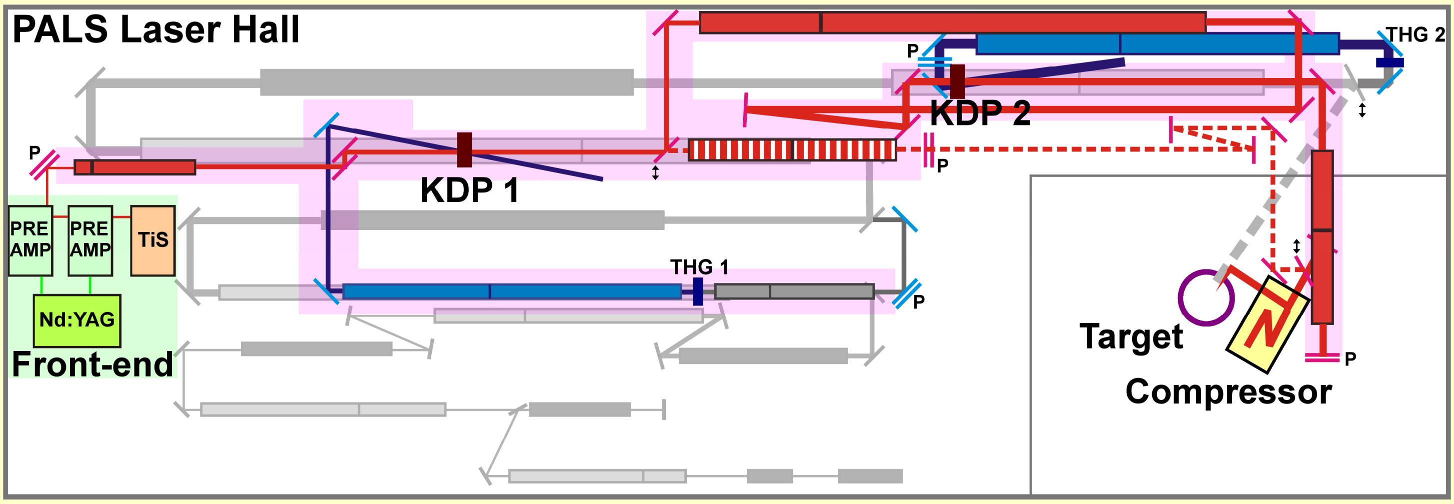


Fig. 4 The proposed layout of the ultra-high-power beams in the current PALS laboratory (41 m x 15.5 m). Beamlines: iodine laser (gray), signal (red), pumps of the preamplifiers (green) and the power amplifiers (blue); rectangles: image relaying telescopes (framed), TH generators (dark blue), KDP power amplifiers (brown), and pulse compressor (yellow); shading: front-end (light green) and stage (pink). The PALS laser, the four front-end optical tables, and the pulse compressor are on the ground floor. The periscopes (P) change a beam elevation. The movable mirrors with the arrows switch between the 100 TW (dashed) and 1 PW beamlines. Sizes of the elements are enlarged for a visibility.

4. Summary

The new 100 TW and 1 PW beams in the PALS laser hall were designed using PALS laser parameters, including the new front-end, the image relaying between the amplifiers, and the pulse compressor. The ultra-high-power beams will increase the available laser power in the PALS facility to the petawatt level and the intensity up to 10^{22} W/cm². The new beams will provide the users a new class of experiments such as relativistic particle acceleration, relativistic optics, laboratory astrophysics, and fast ignition schemes.

5. Acknowledgements and Reference

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[1] Matoušek, P., et al., Design of a Multi-Petawatt Optical Parametric Chirped Pulse Amplifier for the Iodine Laser ASTERIX IV, IEEE Journal of Quantum Electronics, 36 158 (2000)