Burst mode pulse generation from fiber lasers (for accelerator facilities)

F. Ömer Ilday

Department of Physics, Bilkent University, Ankara, Turkey

http://ultrafast.bilkent.edu.tr

Ultrafast Optics & Lasers Laboratory (UFOLAB)

Research Areas:

Mode-locked laser oscillators

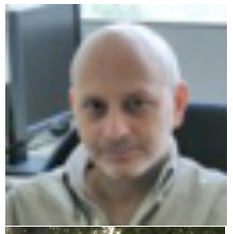
High-energy and high-power fiber amplifiers

Ultrafast material/tissue processing

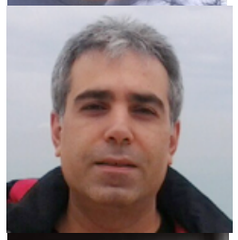
Neurophotonics applications

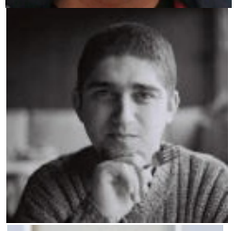
UFOLAB Researchers

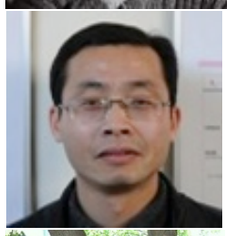
Postdoctoral Researchers


Dr. Hamit Kalaycıoğlu


Dr. Ihor Pavlov


Dr. Parviz Elahi

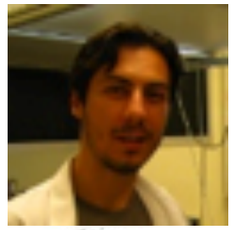

Dr. Zuxing Zhang


Dr. Daniel Press


Dr. Onur Tokel
(to join in June)

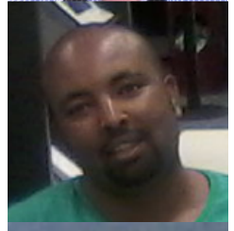
* Co-advised

PhD Students


Mutlu Erdoğan *

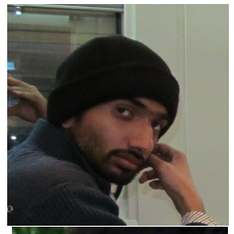

Can Kerse *

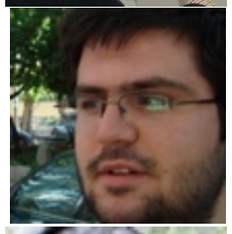

Andrey Rybak

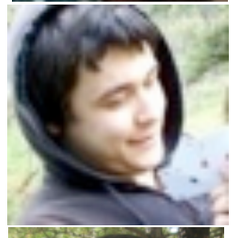

Tesfay Teamir


Seydi Yavaş

MS Students


M. Wakas Akbar *


Burak Eldeniz *


Kutan Gürel


Ahmet Turnalı *

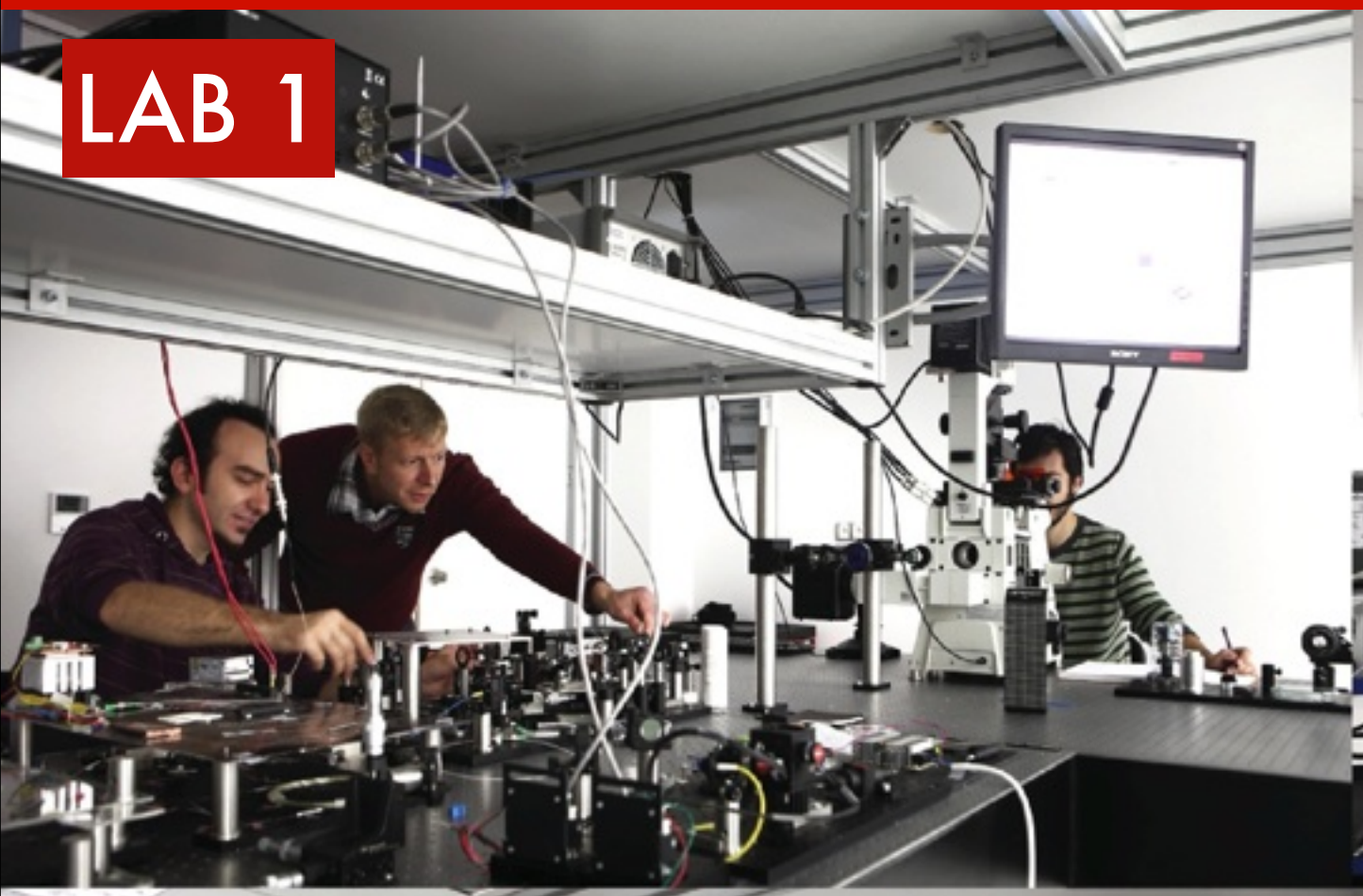

Sinem Yılmaz

Technical Staff


Önder Akçaalan

Ultrafast Optics & Lasers Laboratory (UFOLAB)

LAB 1



LAB 2

LAB 3

LAB 4

Cs atomic clock-stabilized fiber comb at 1 μm

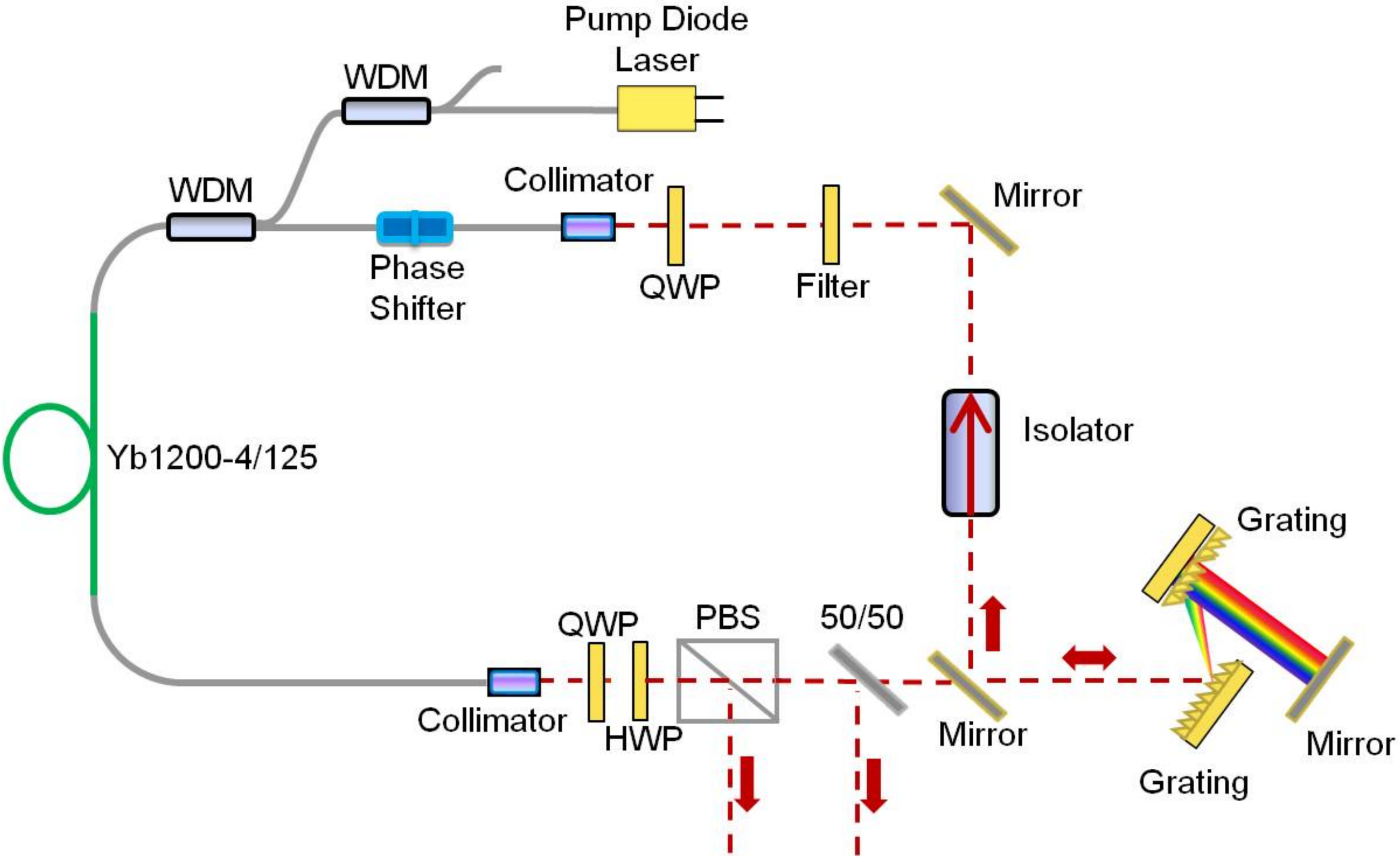
100-W, 5-ps fiber laser via doping management

High-energy burst-mode fiber laser

Burst-mode laser-material interaction

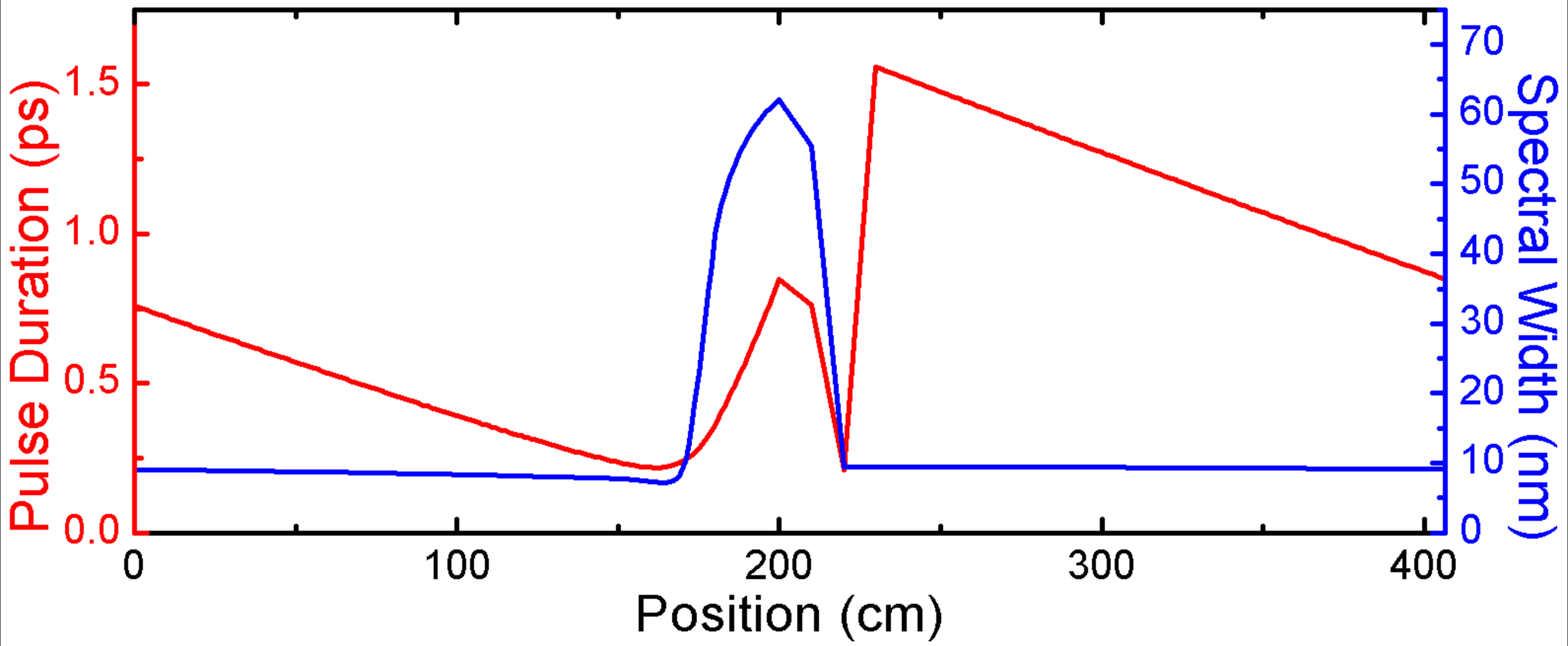
Speculation time

New ultrashort laser at 1 μm with exactly 0 dispersion



Collaboration with Dr. Hamid's group at the National Metrology Institute of Turkey

Pulse evolution: similariton + spectral compression + dispersive



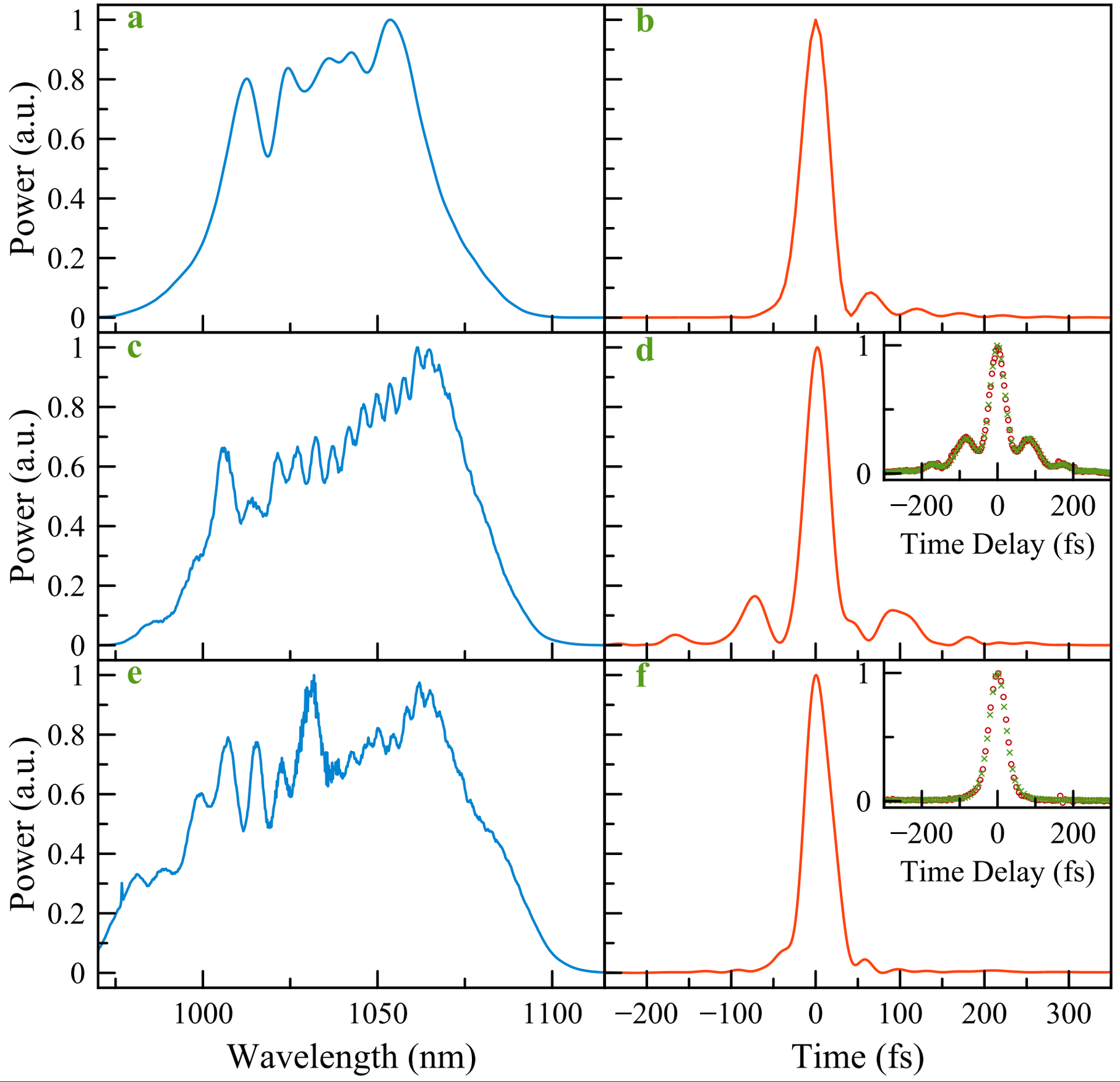
Ç. Şenel, et al., in preparation

35 fs pulses are generated and preserved during amplification

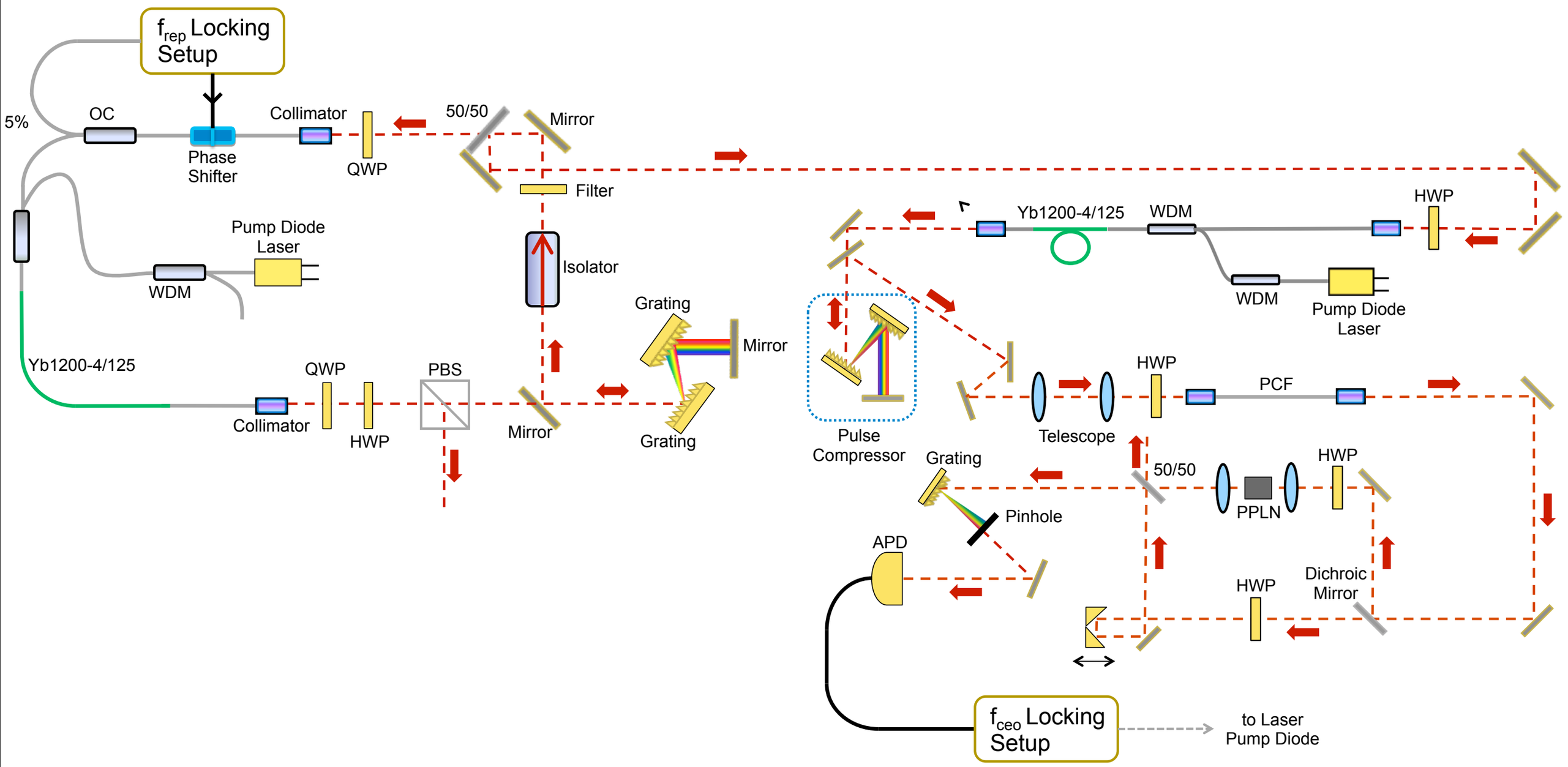
simulation: oscillator

experiment: oscillator

experiment: amplifier

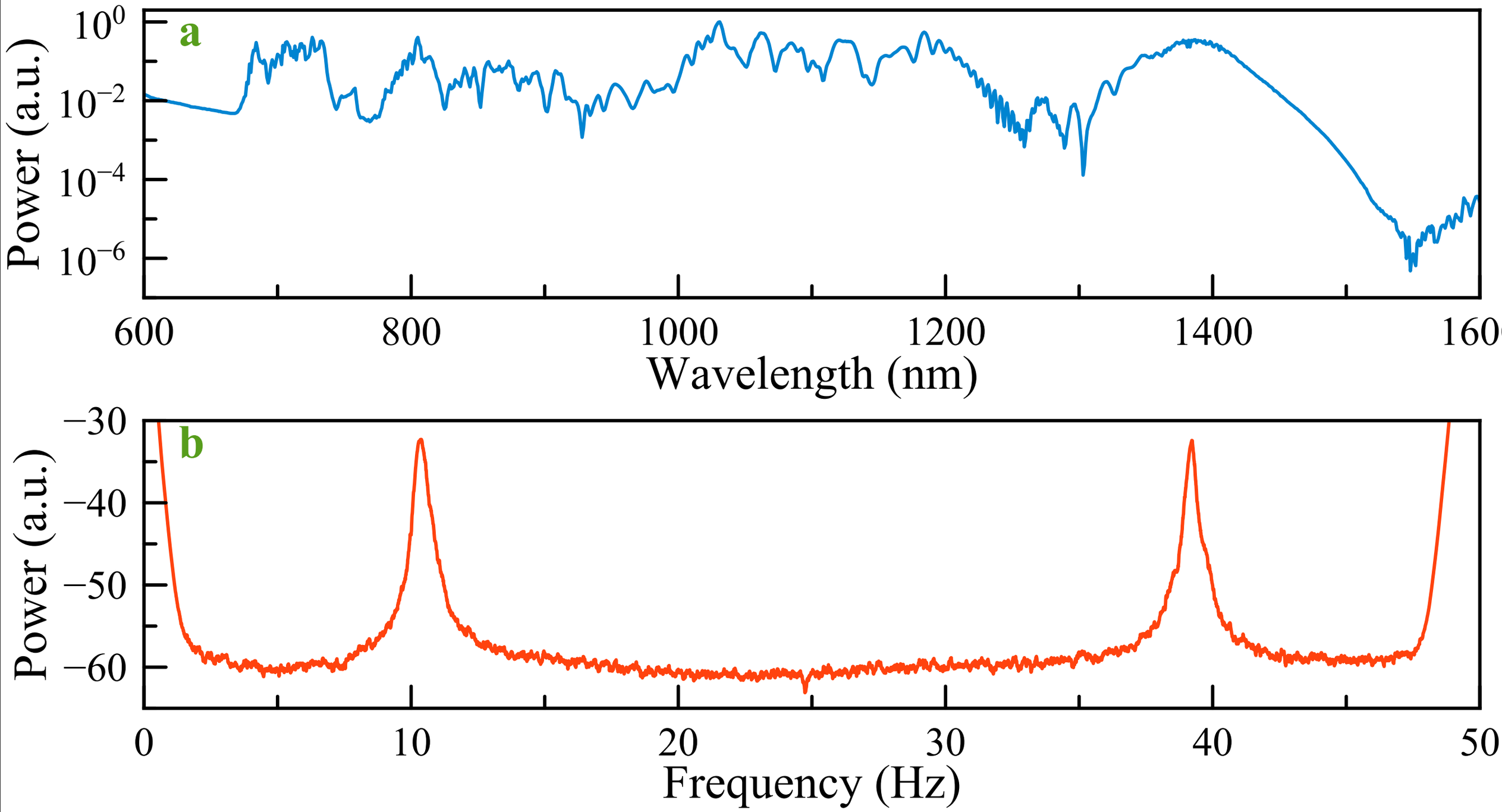


Fully stabilized frequency comb locked to Cs atomic clock

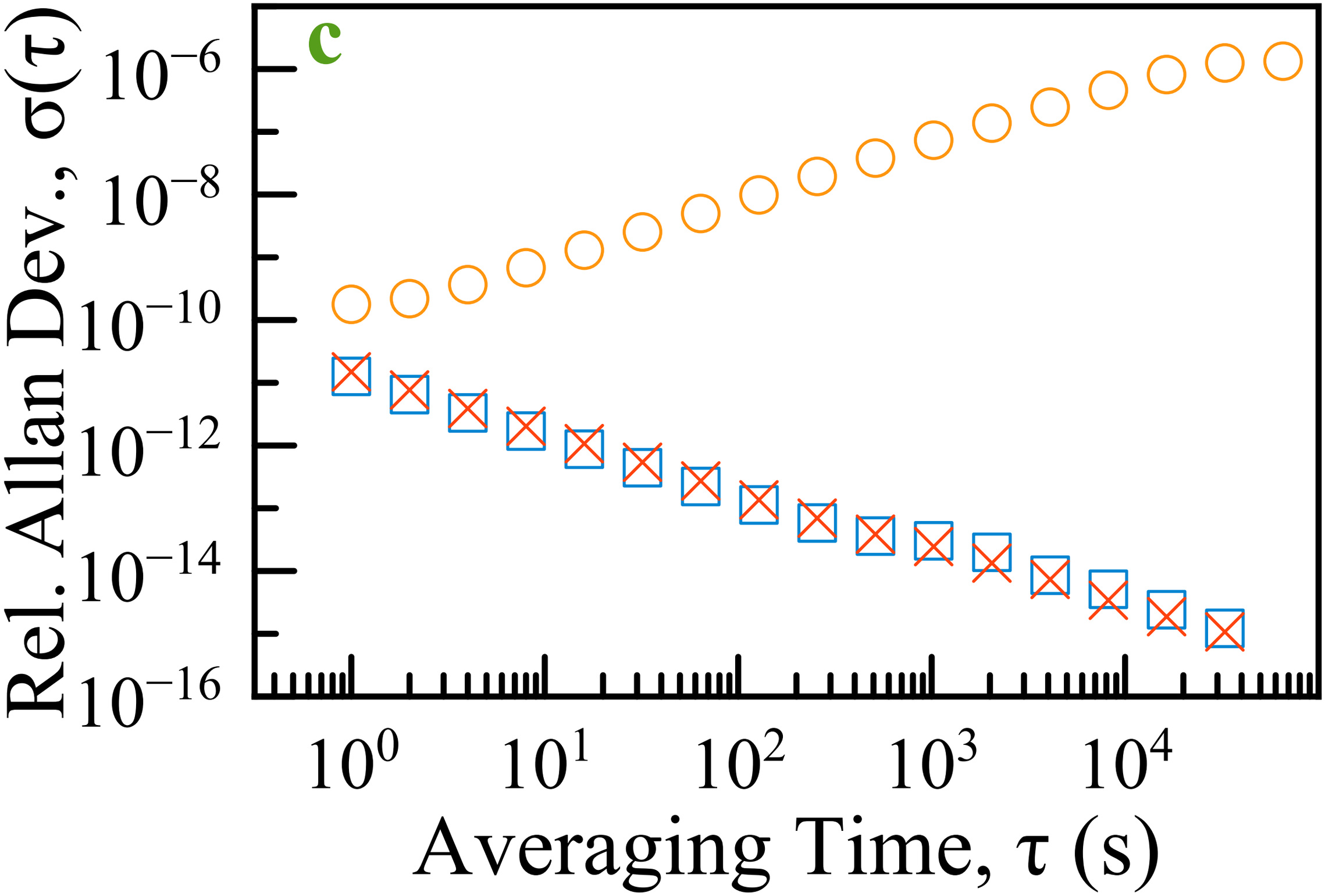


Ç. Şenel, et al., in preparation

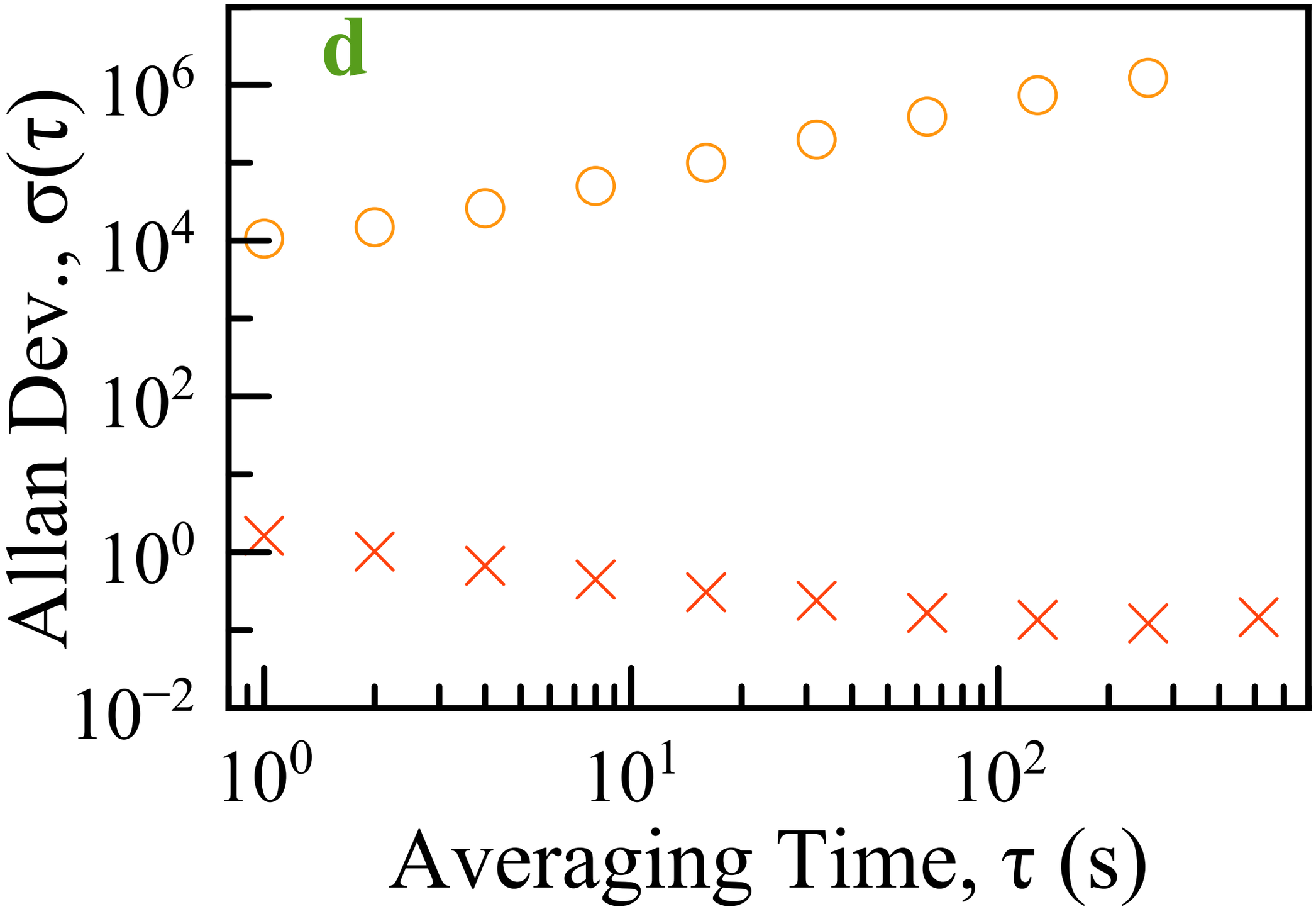
Supercontinuum generation and f-2f beat



Repetition frequency stability



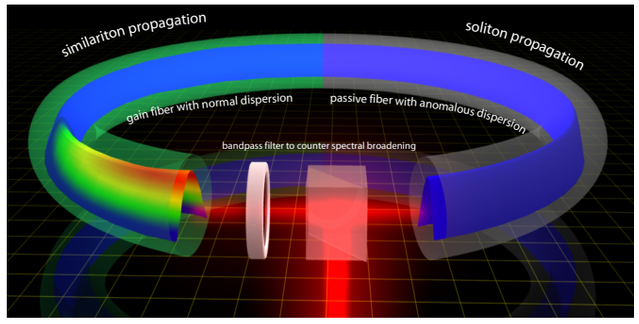
Offset frequency stability



Recent work in fiber oscillators

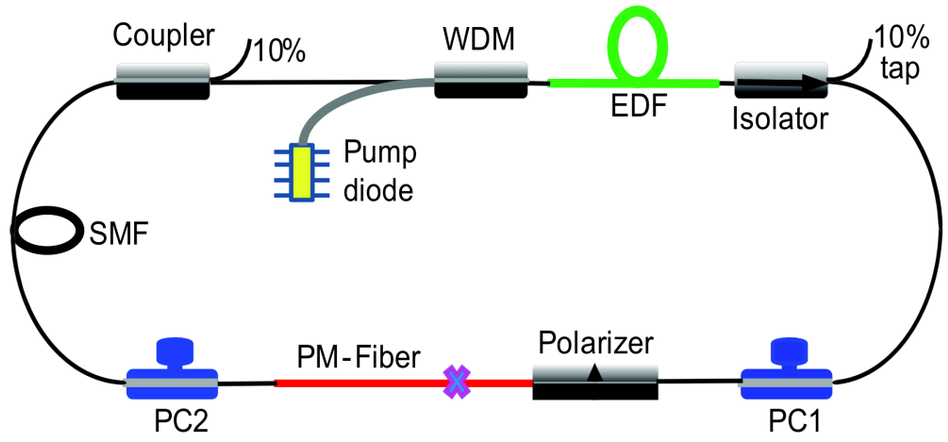
Replace bulk filter with PM fiber as filter

K. Özgören, F. Ö. Ilday, Opt. Lett. 35, 1296 (2010)



First soliton-similariton laser

B. Oktem, et al., Nature Photon. 4, 307 (2010)

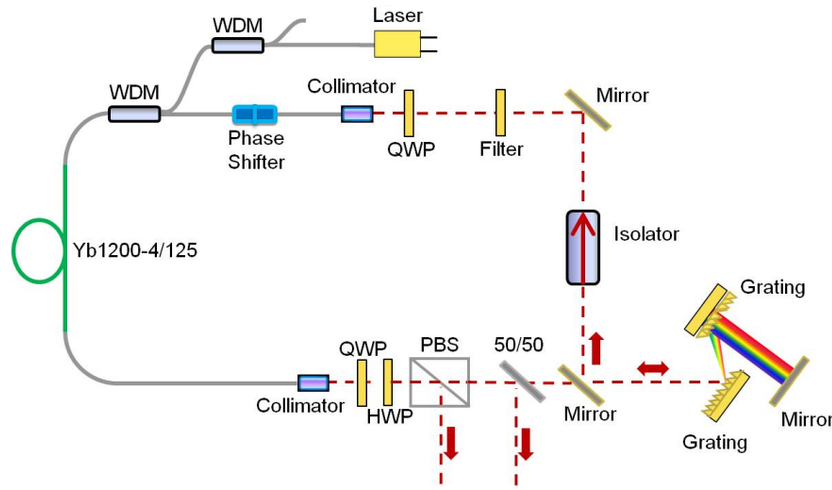


First all-fiber soliton-similariton laser

Z. Zhang, et al., Opt. Lett. 37, 3489 (2012)

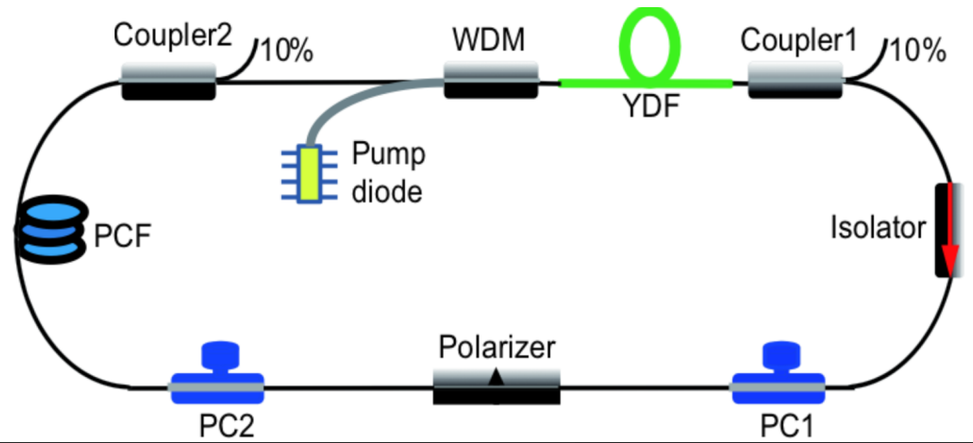
Zero-dispersion laser with 35-fs pulses

Ç. Şenel, et al., in preparation



All-fiber Yb-laser with PCF

Z. Zhang, et al., to appear in Opt. Lett.



Cs atomic clock-stabilized fiber comb at 1 μm

100-W, 5-ps fiber laser via doping management

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Burst-mode laser-material interaction

Speculation time

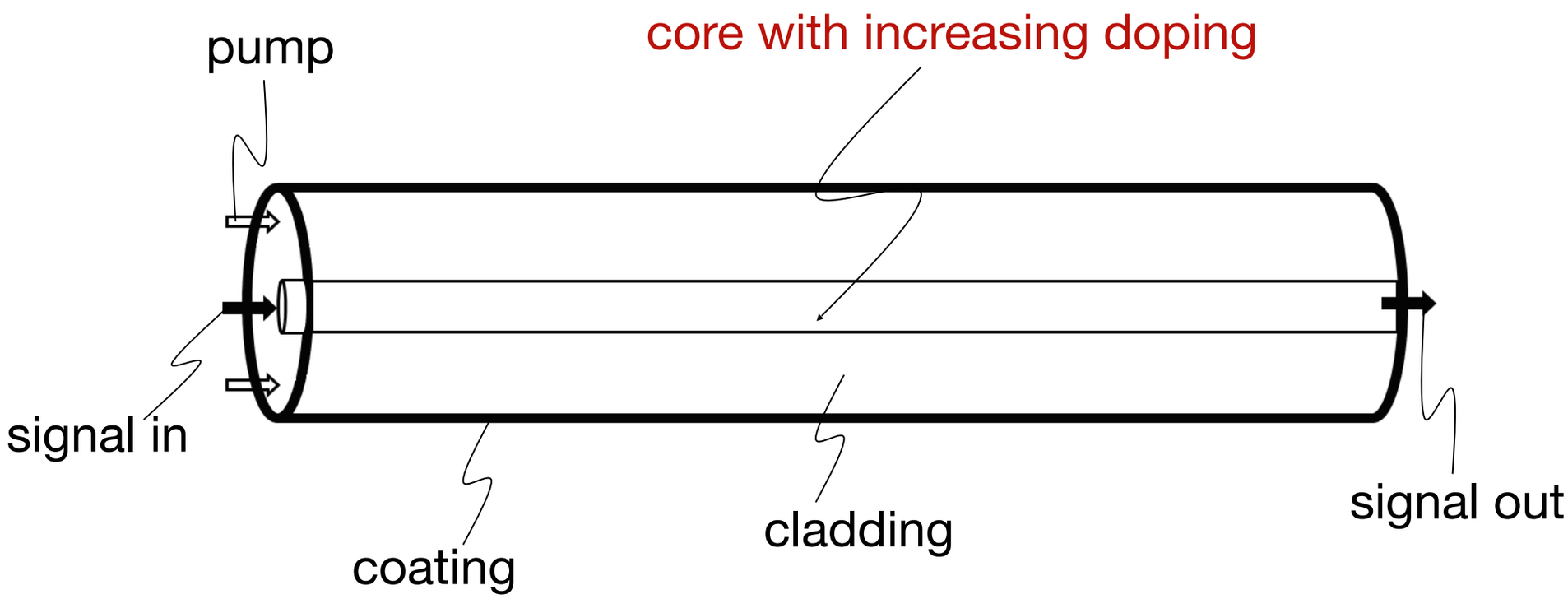
Doping Management

Trade-off between thermal and nonlinear effects:

To handle thermal effects, best to use low-doped, long gain fibers

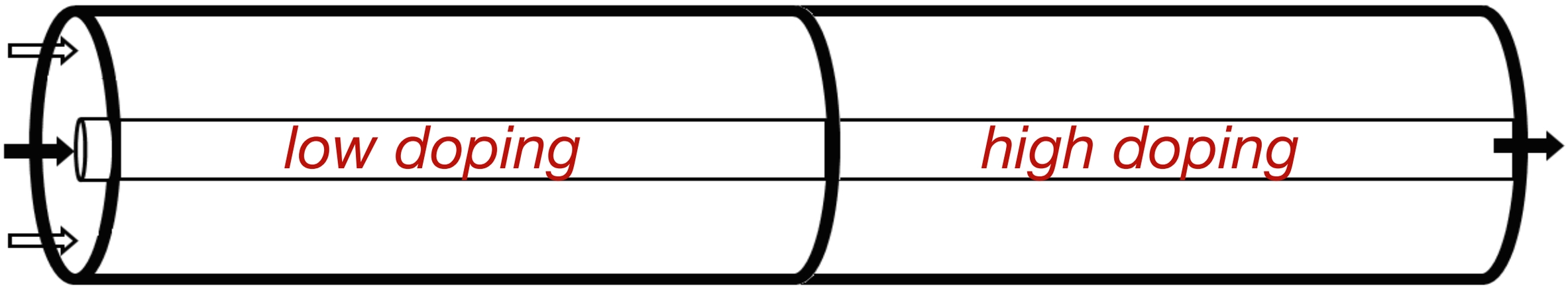
To handle nonlinear effects, must minimize fiber length with high doping

Doping Management: vary the doping level along the fiber



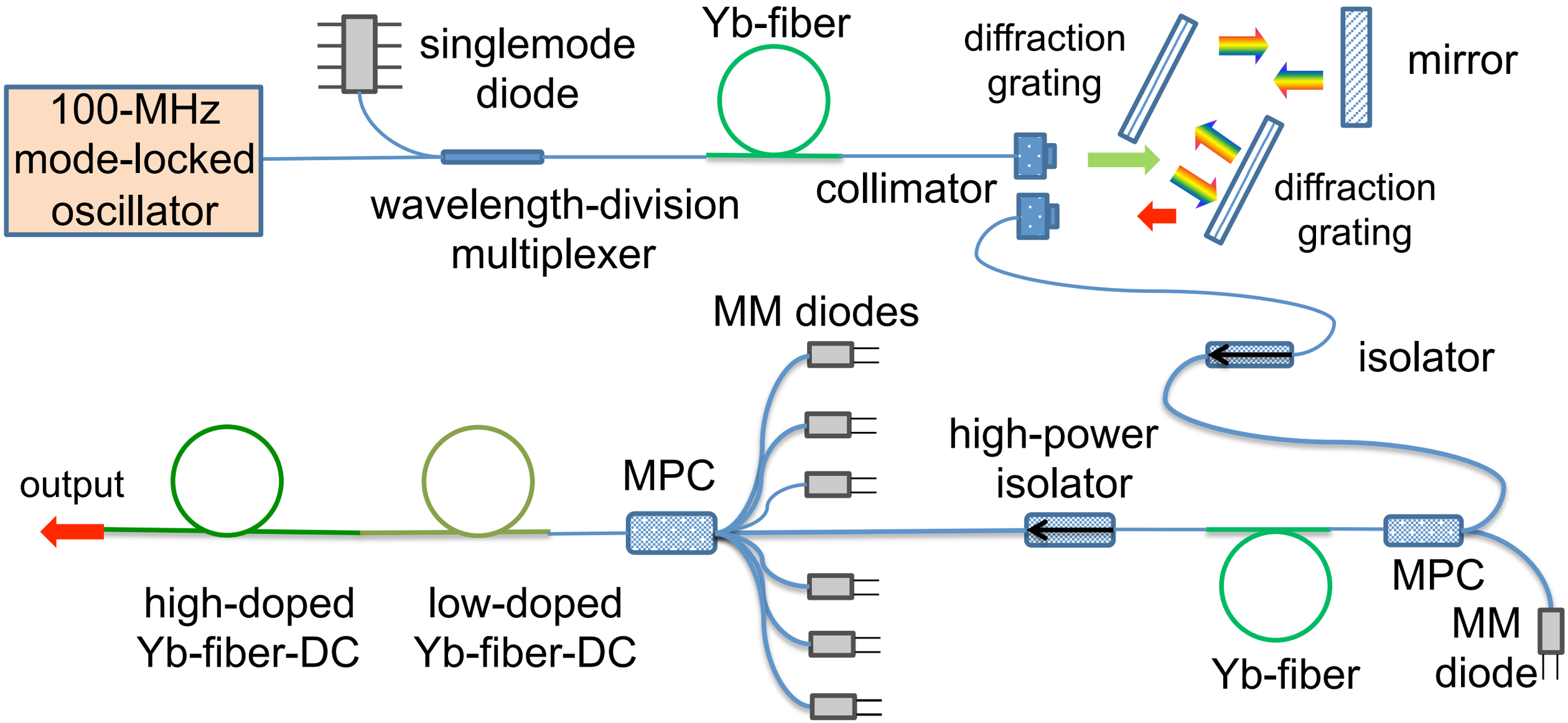
Discrete Doping Management

Splice a high-doping and a low-doping fiber together

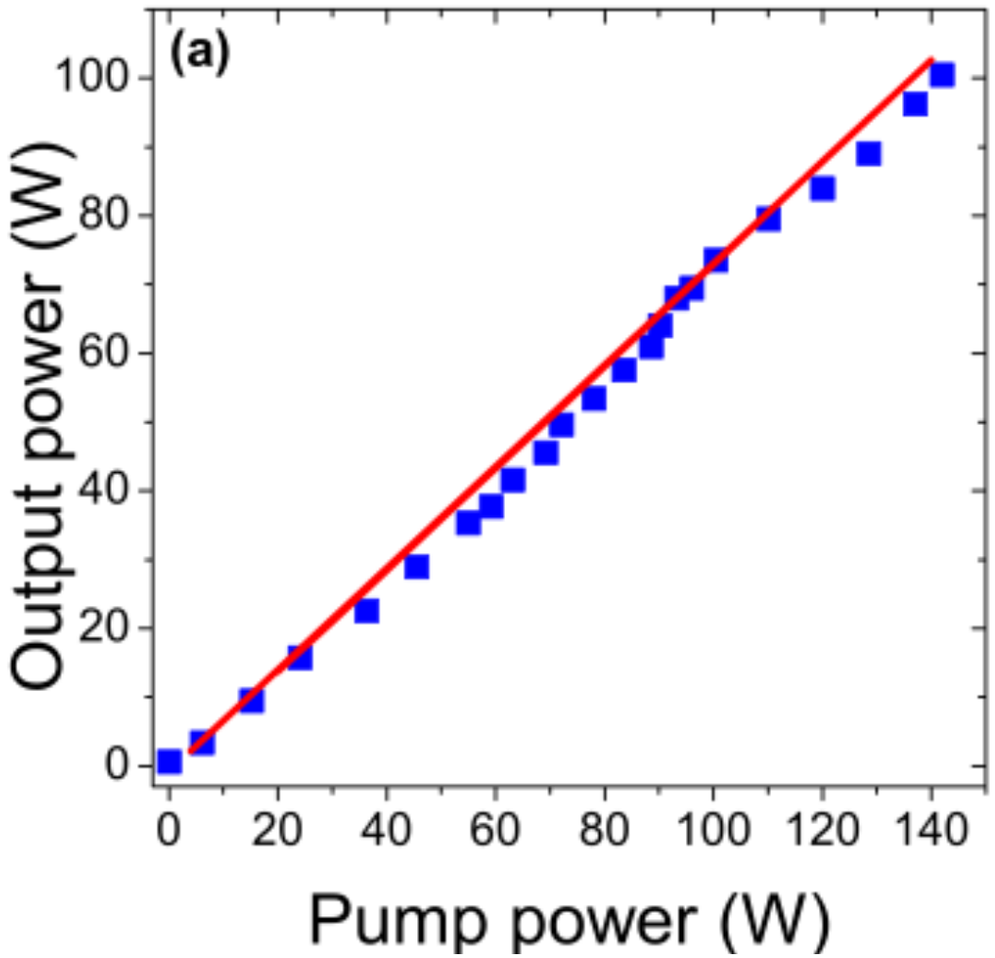


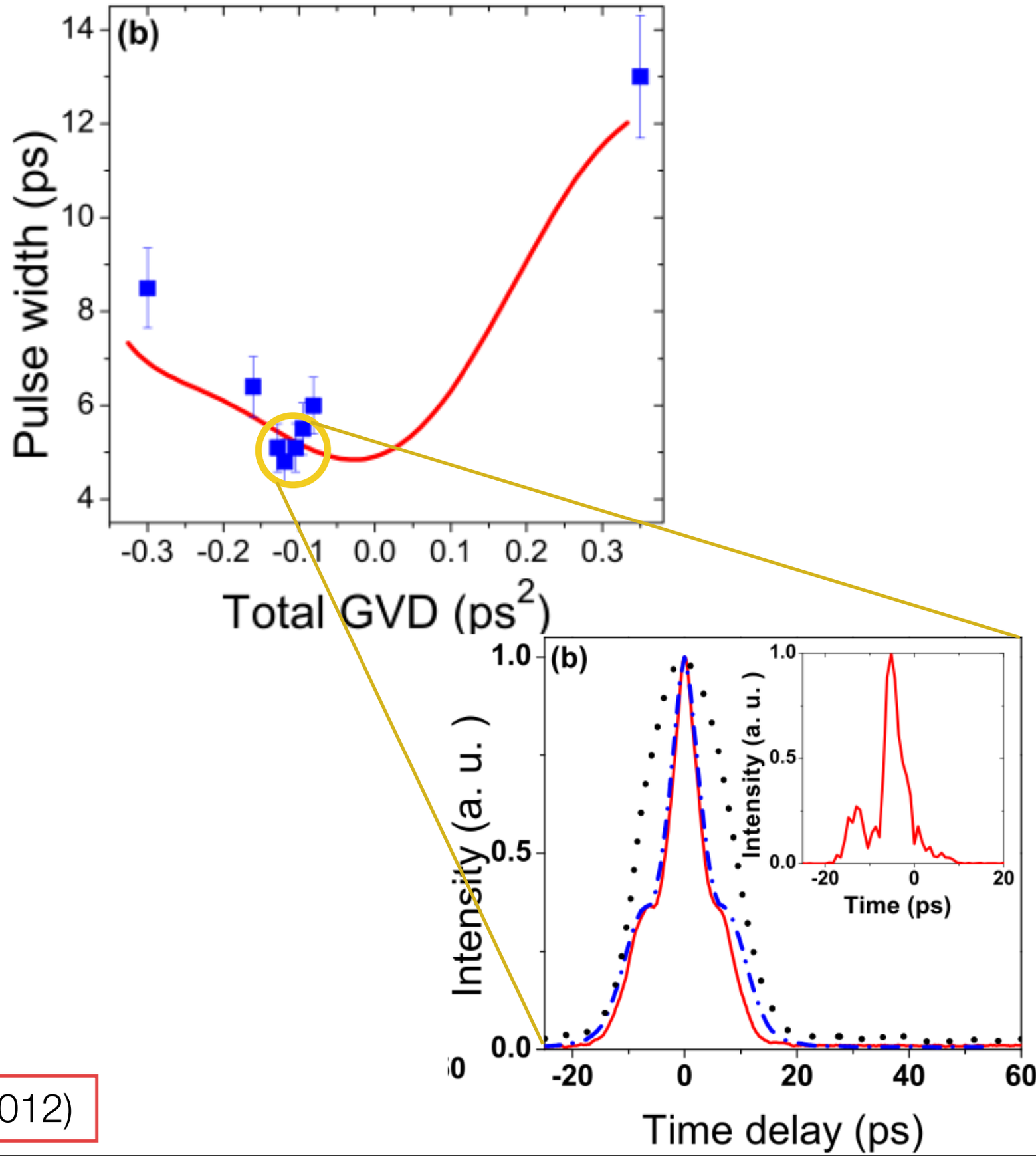
P. Elahi, et al., Opt. Lett., 37, 3042 (2012)

Towards high-power ultrafast pulses: 100 W, 5 ps, 100 MHz



Initial results: 100 W, 5 ps, 100 MHz





P. Elahi, et al., Opt. Lett., 37, 3042 (2012)

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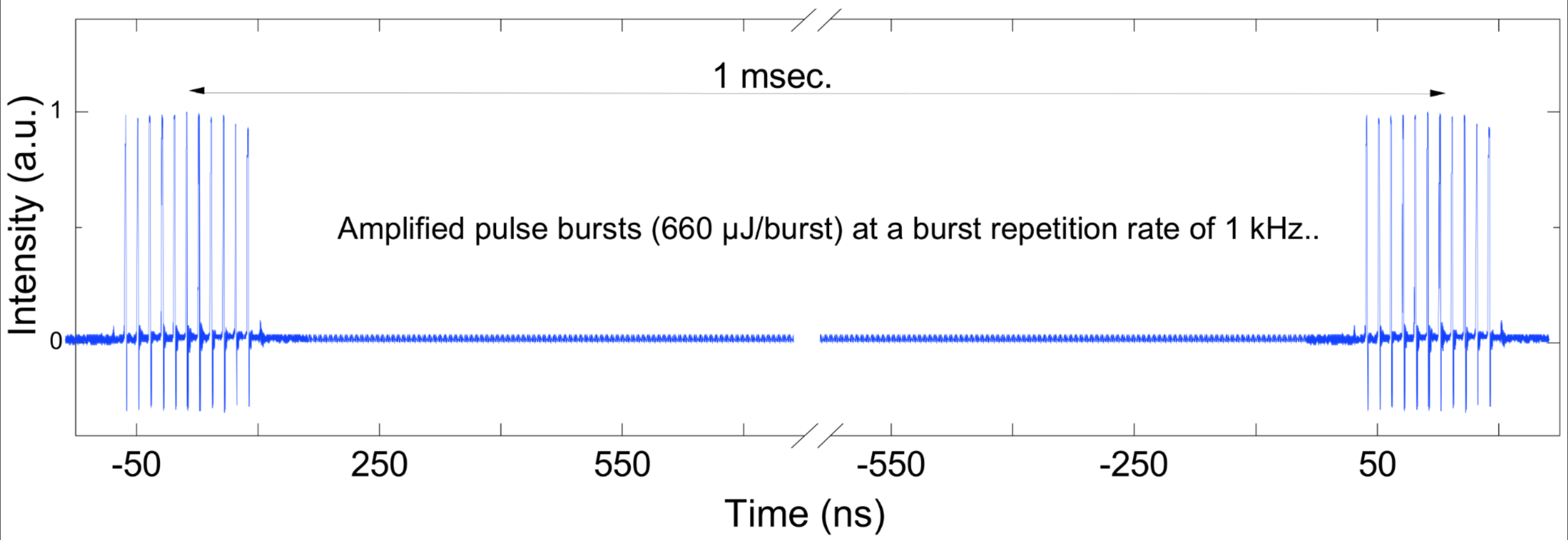
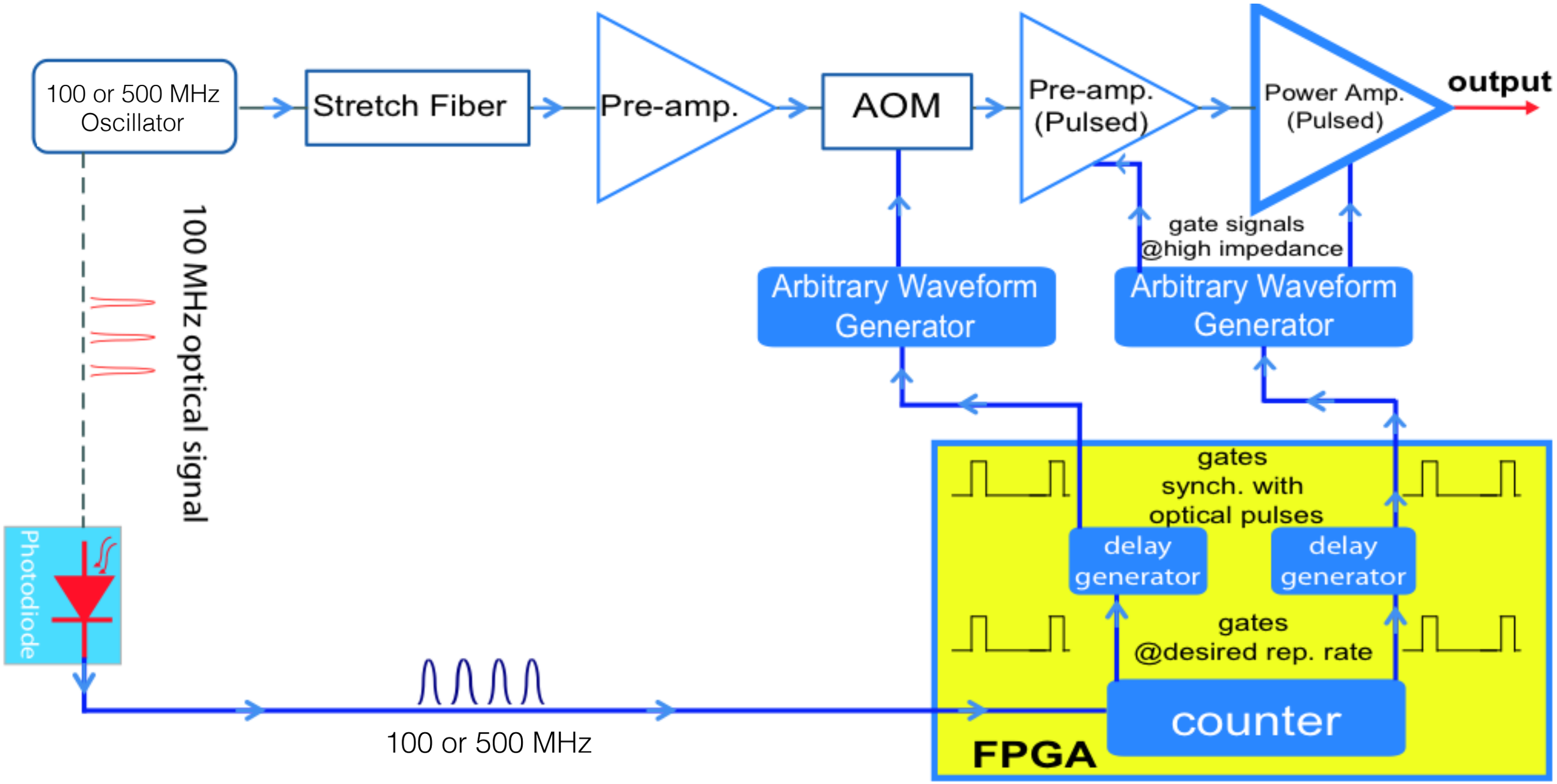
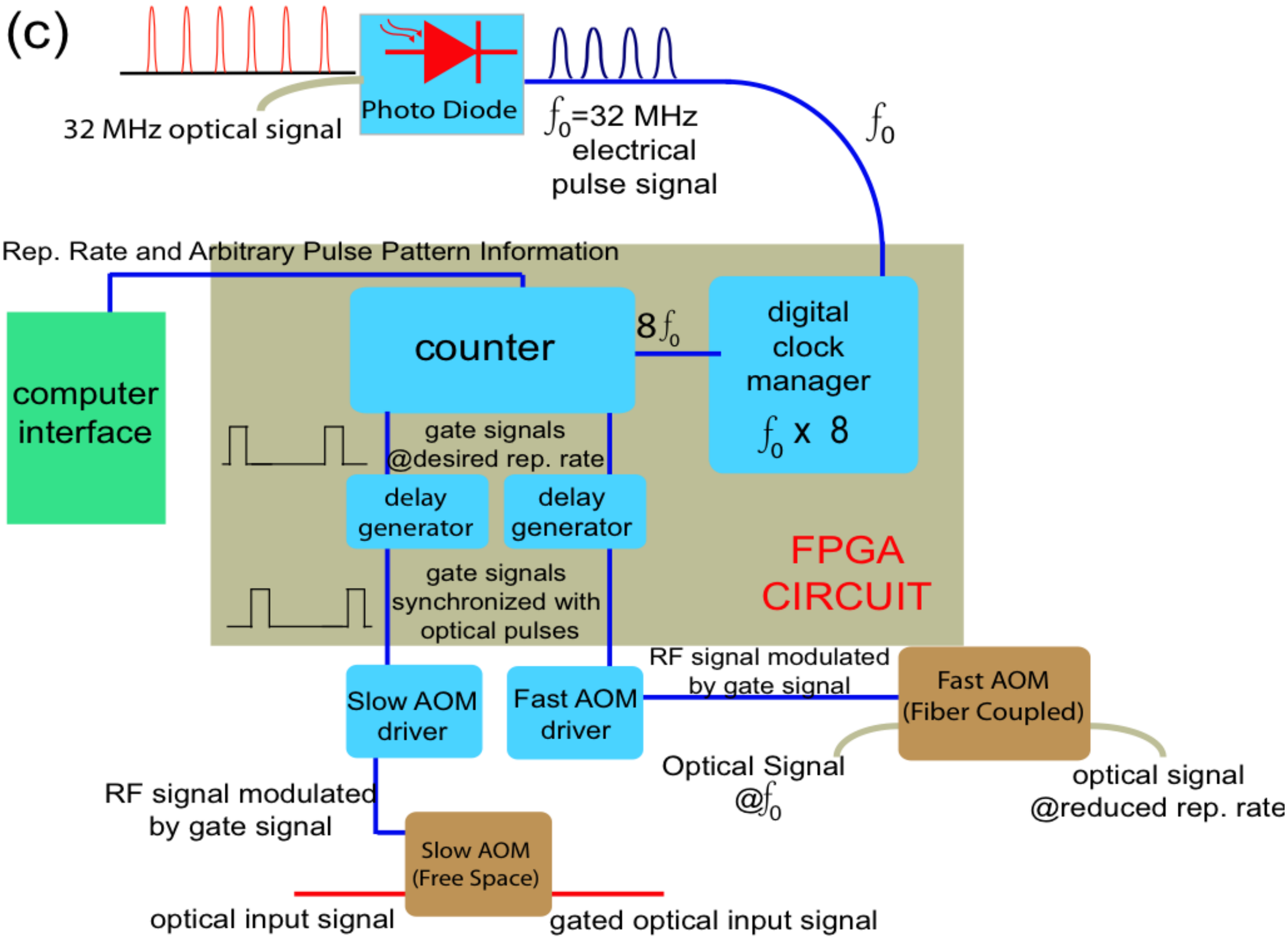
Burst mode laser system with pulsed pumping



Burst mode laser system with pulsed pumping

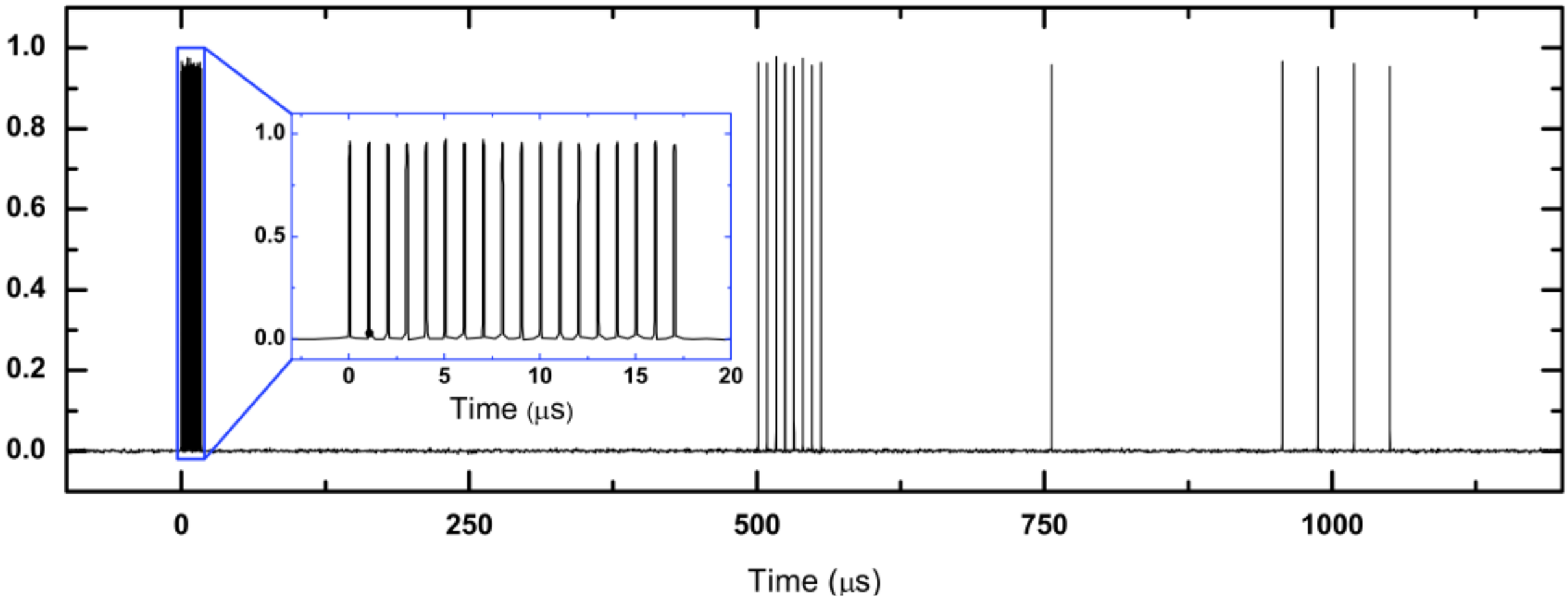


Arbitrary pulse train synthesis with FPGA + AOM



Arbitrary pulse train synthesis with FPGA + AOM

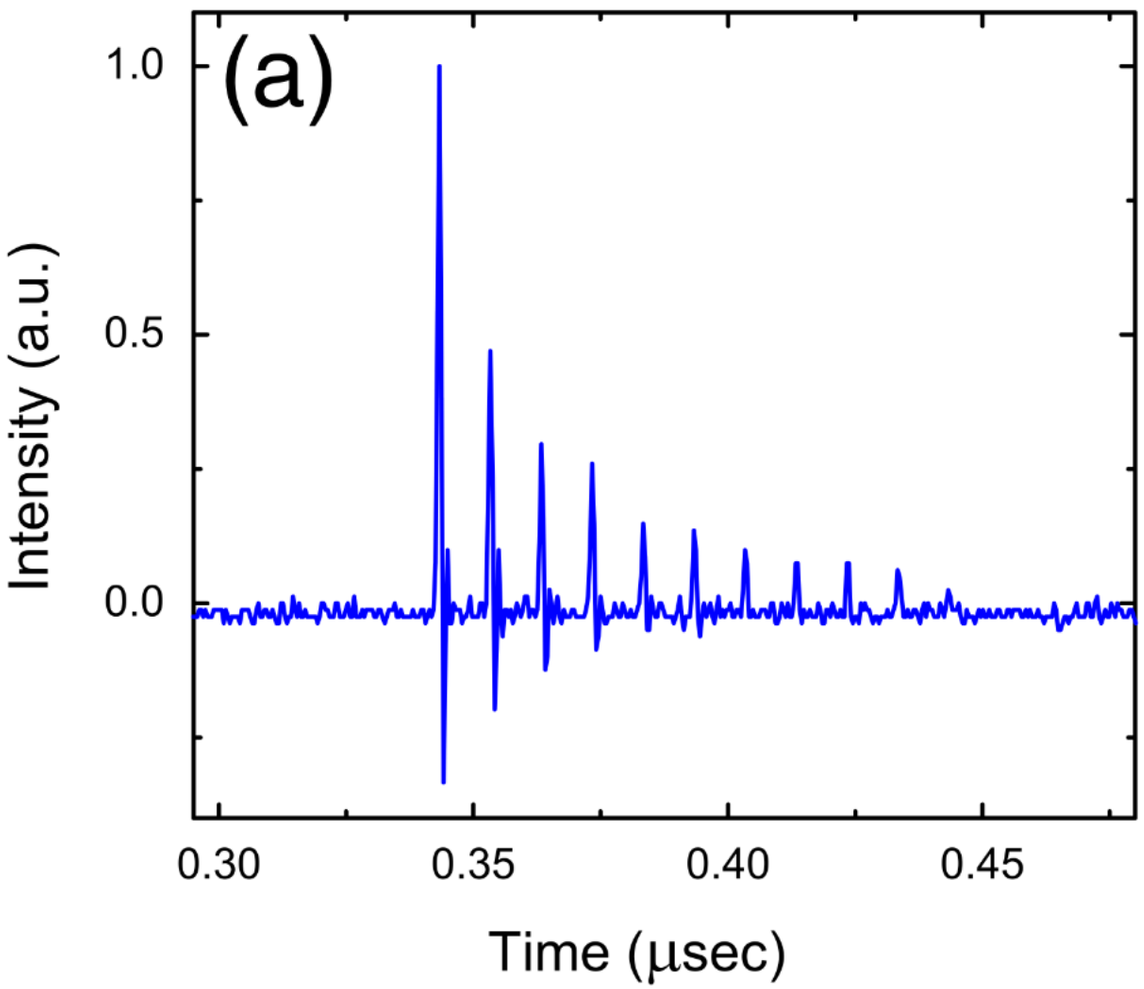
Developed a technique (using FPGAs) to synthesize pulse sequences.



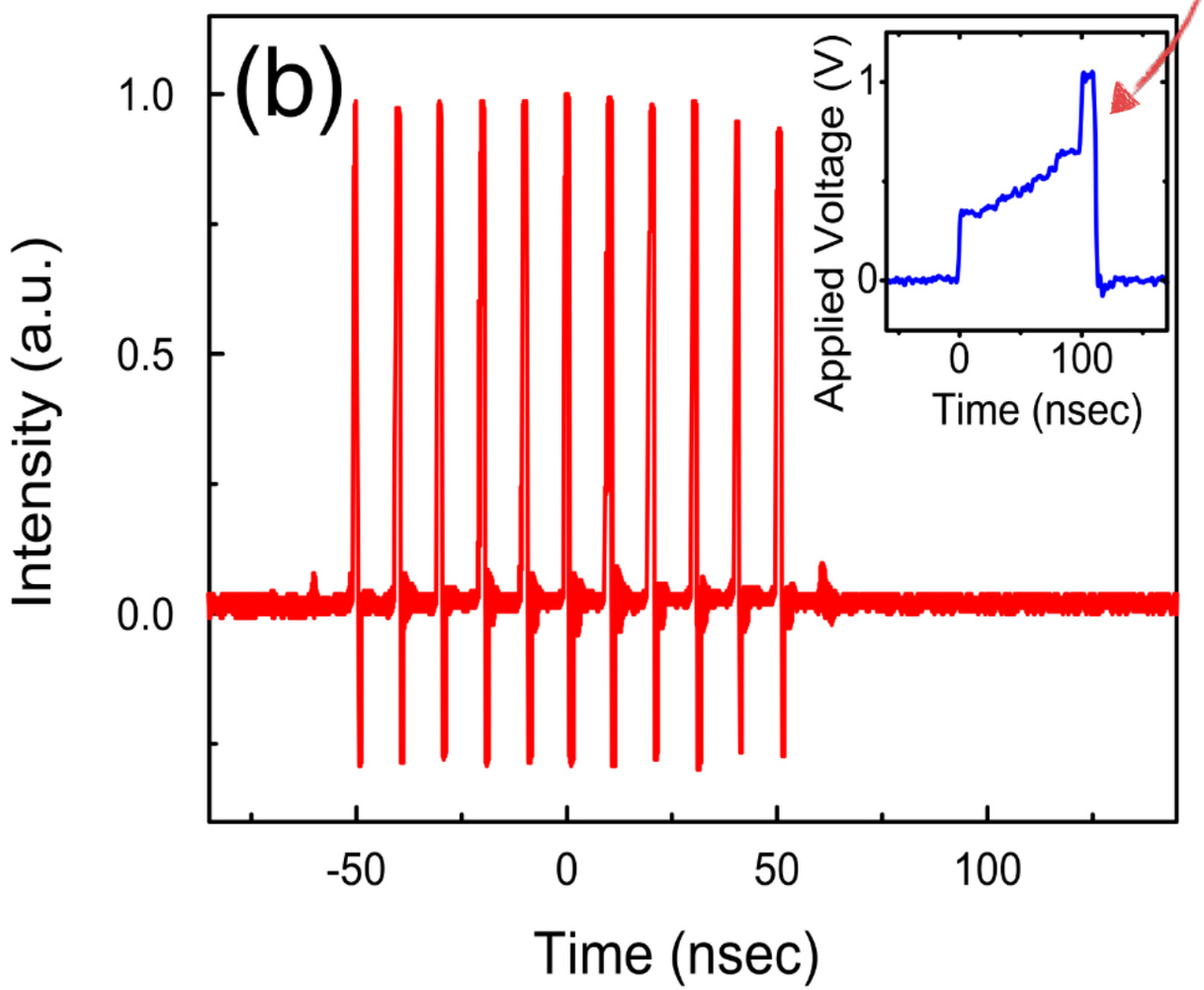
S. Yavaş, et al., Biomed. Opt. Express 3, 605 (2012).

Preshaping to balance gain saturation

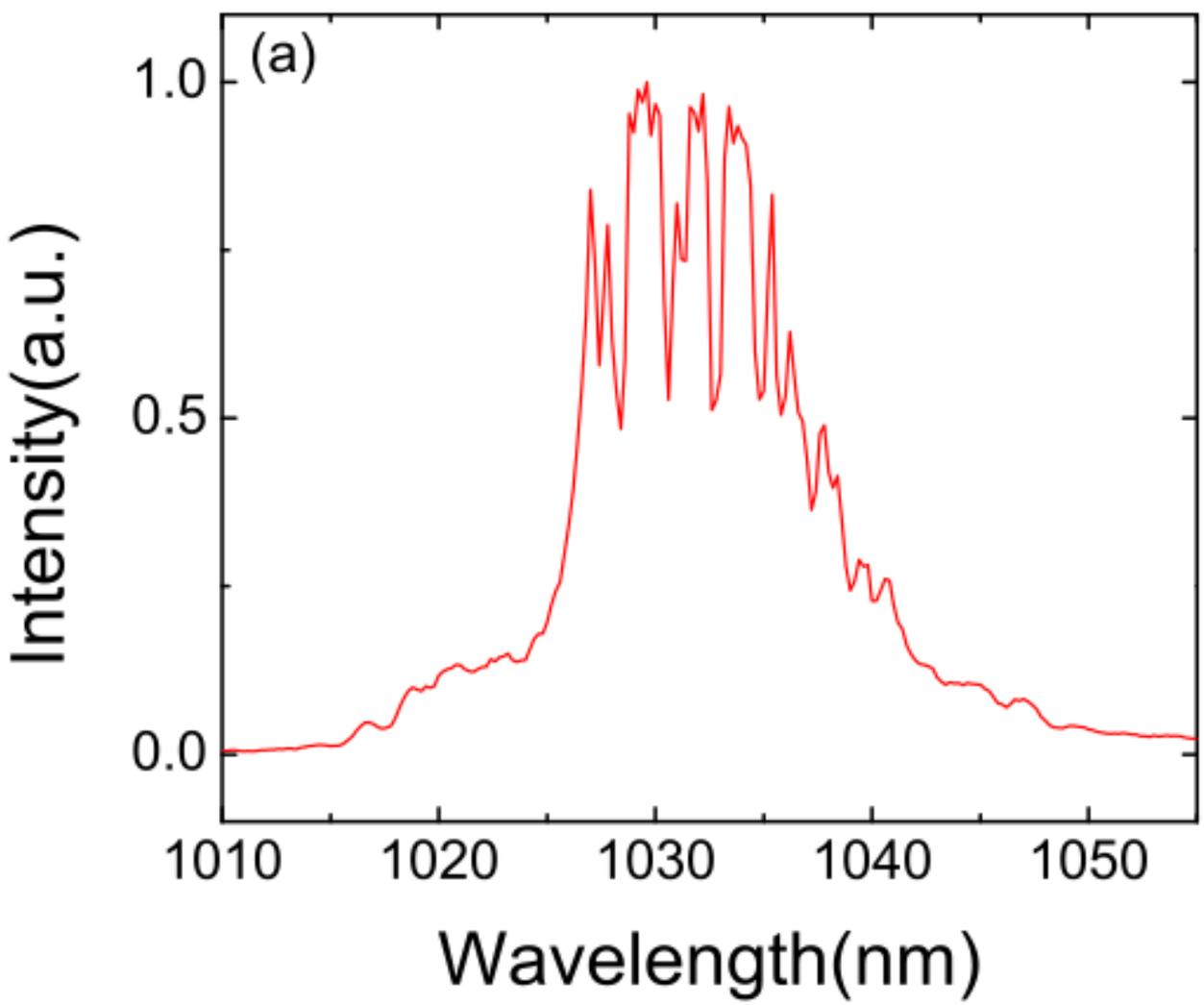
no preshaping

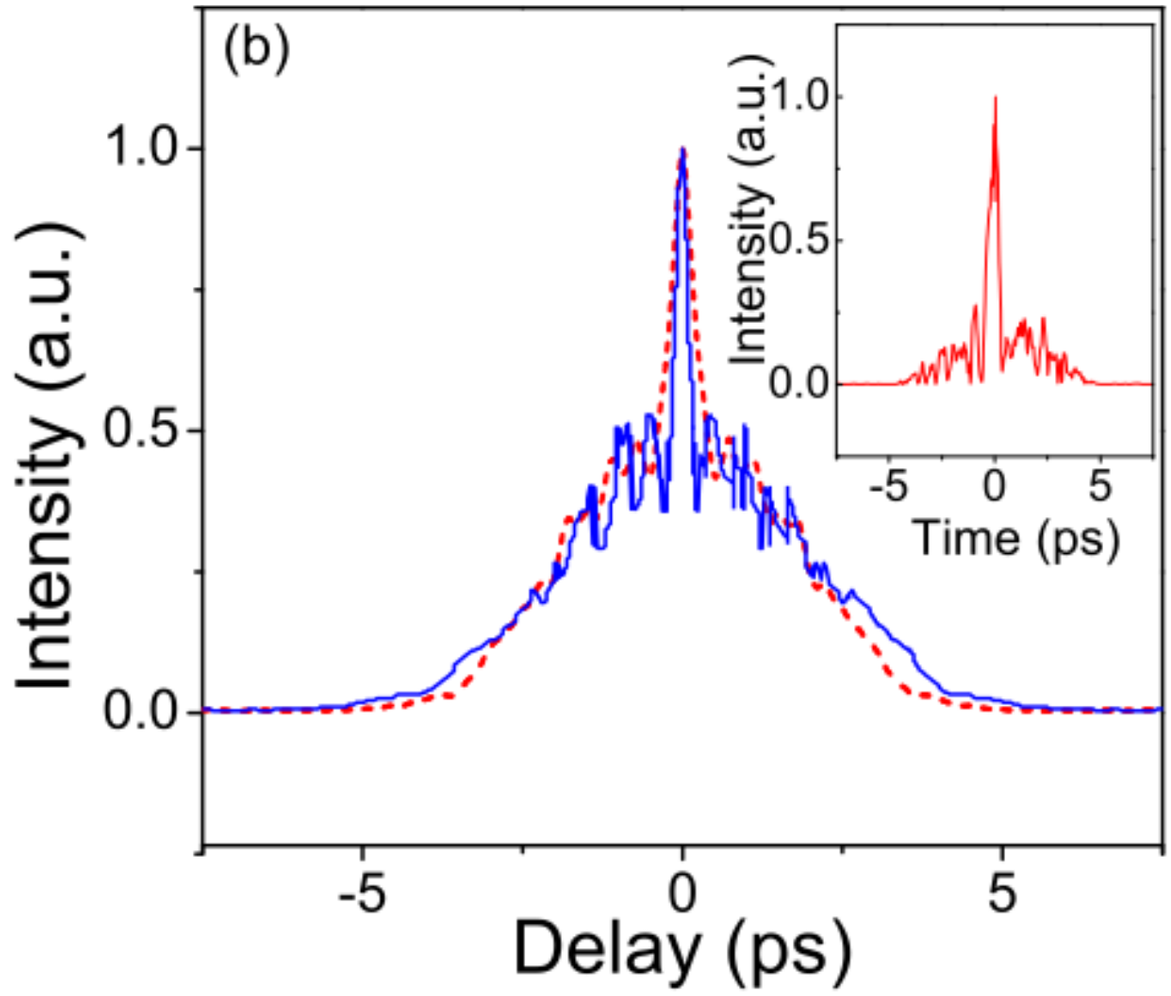


with preshaping



1 mJ burst energy, <1 ps pulses





H. Kalaycioglu, et al., Opt. Lett. 37, 2586 (2012)

H. Kalaycioglu, et al., Opt. Lett. 36, 3383 (2011)

H. Kalaycioglu, et al., Opt. Lett. 35, 959 (2010)

Cs atomic clock-stabilized fiber comb at 1 μm

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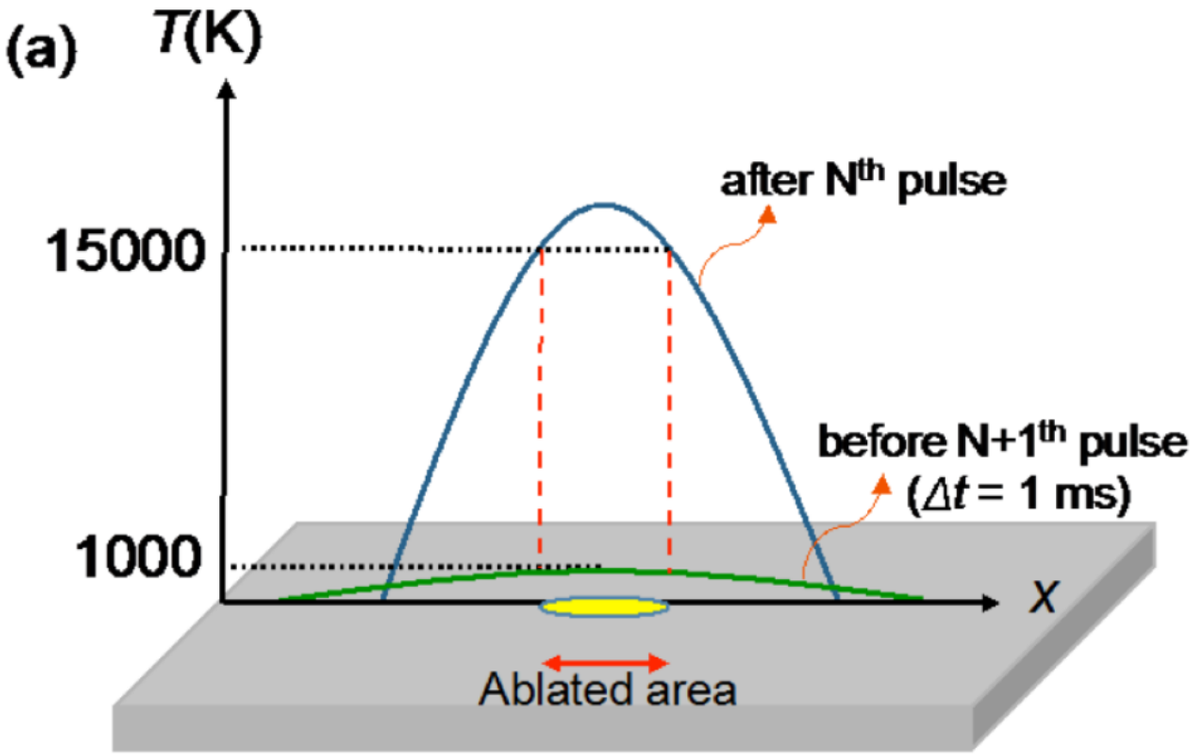
High-energy burst-mode fiber laser

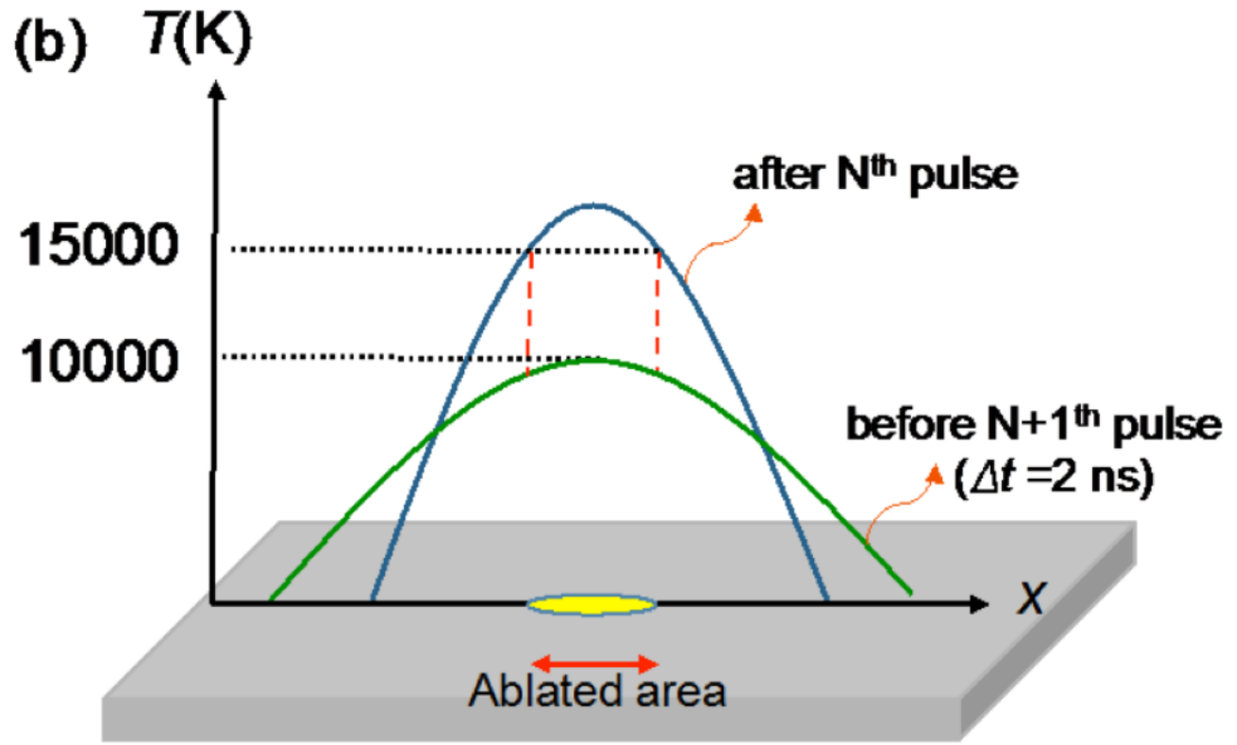
Burst-mode laser-material interaction

Speculation time

An unexplored physical regime: ultrahigh repetition rates



1-kHz ultrafast laser



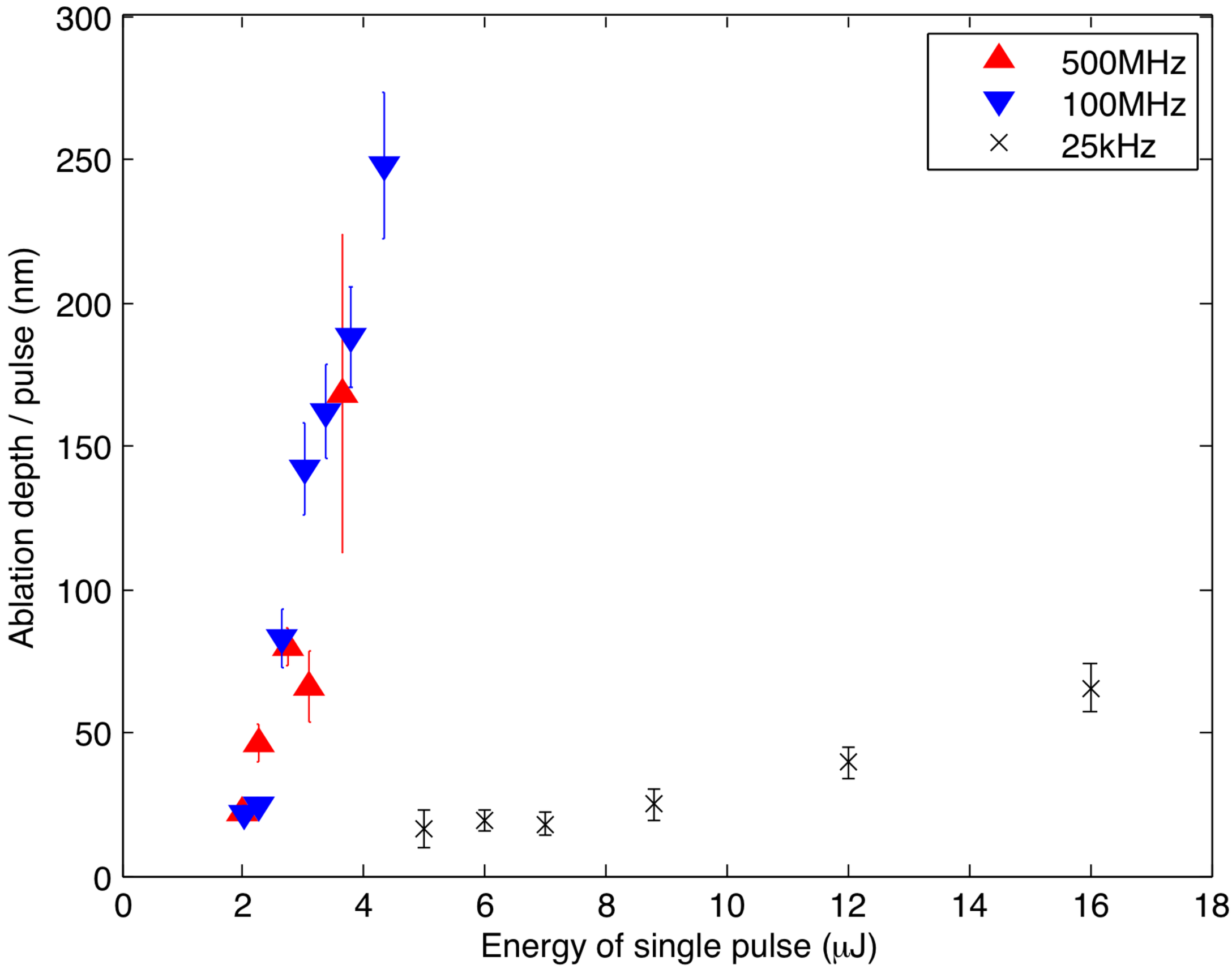
500-MHz ultrafast fiber laser

need:
~0.1-1 J/cm^2
~0.1-1 TW/cm^2

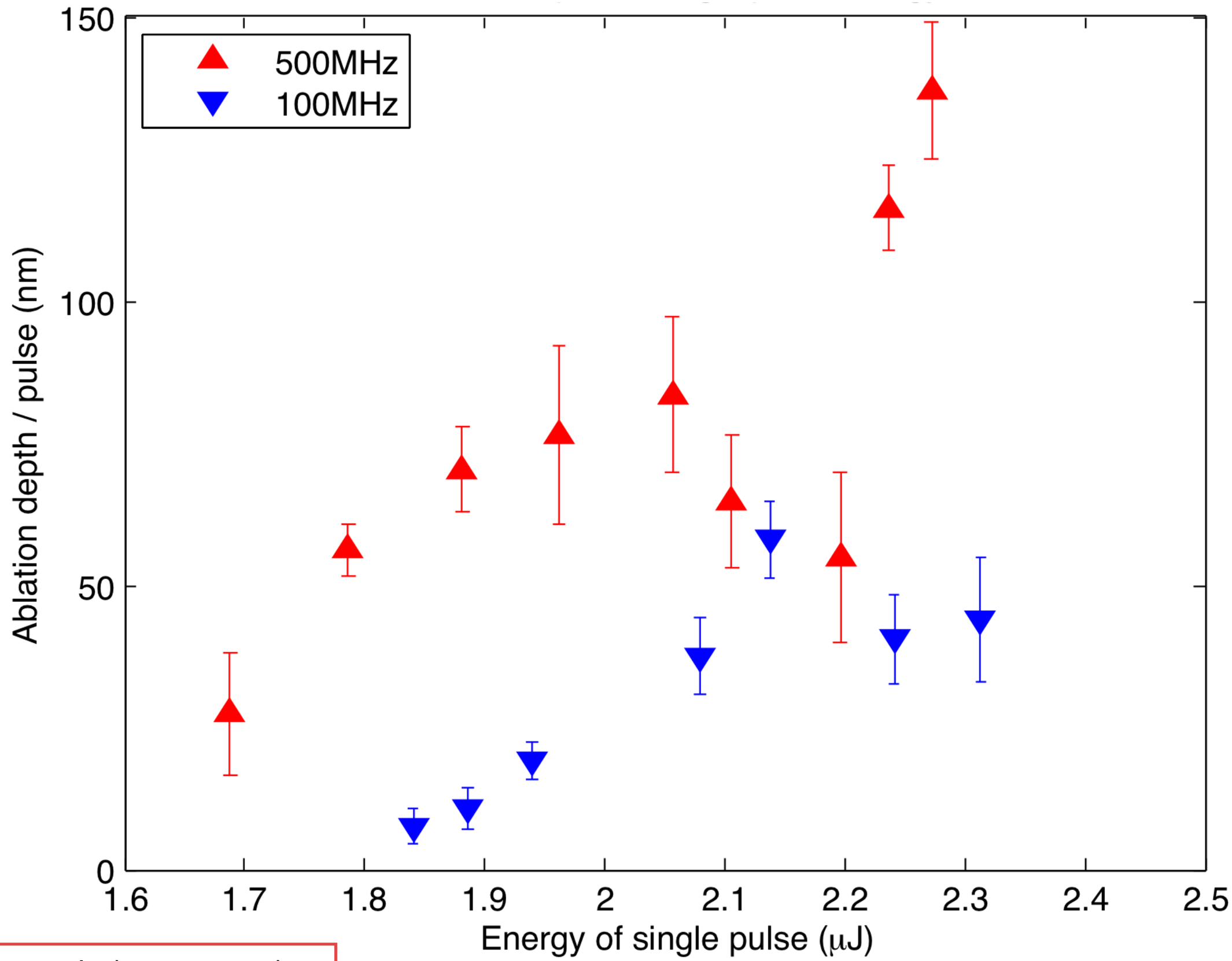
→

for 100 μm^2:
~0.1-1 MW

Ablation rate per pulse: burst mode vs. uniform mode



Burst-mode ablation rates: 100 MHz vs. 500 MHz



C. Kerse, et al., in preparation

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Speculation time

Multi-photon emission from photocathodes?

Does multi-photon emission make sense for photoinjectors?

If yes, fiber lasers might be ideal.

Basic intuition:

frequency doubling/tripling efficiency ~ two/three-photon process

P. Musumeci, C. Vicario, et al., Phys. Rev. Lett. 104, 084801 (2010).

Does any accelerator need multi-GHz, 10-mJ bursts @ 100 kHz?

If I told you that we can scale up to in a few years:

100 pulses with ~0.1 mJ/pulse at 5-10 GHz repetition rate

100 kHz burst repetition rate ⇒ ~1 kW average power

[It can be seeded by a frequency stabilized oscillator]

Any accelerator application that would demand such a laser?

Thank you

open to collaborations;

reach me now

or later at ilday@bilkent.edu.tr