

1550 nm Femtosecond Fiber Laser System for the Two-Photon Excitation of Transient Currents in Semiconductor Detectors

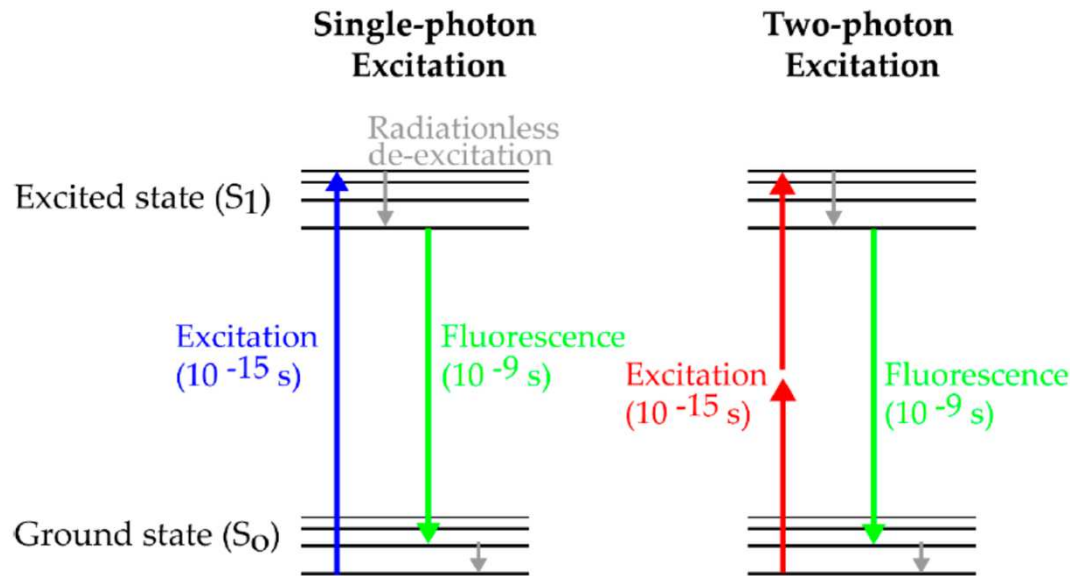
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¹FYLA LASER SL

36th RD50 Workshop



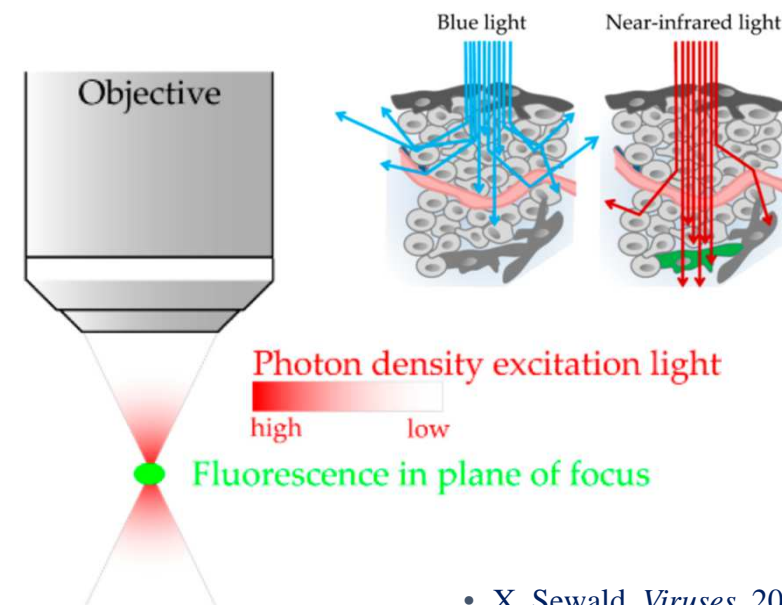
TWO-PHOTON EXCITATION



Application Example

TWO-PHOTON FLUORESCENCE MICROSCOPY

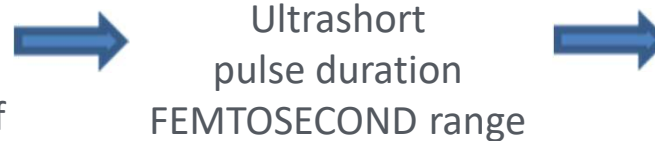
- Deeper penetration
- Point resolution - 3D imaging



• X. Sewald, *Viruses*, 2018.

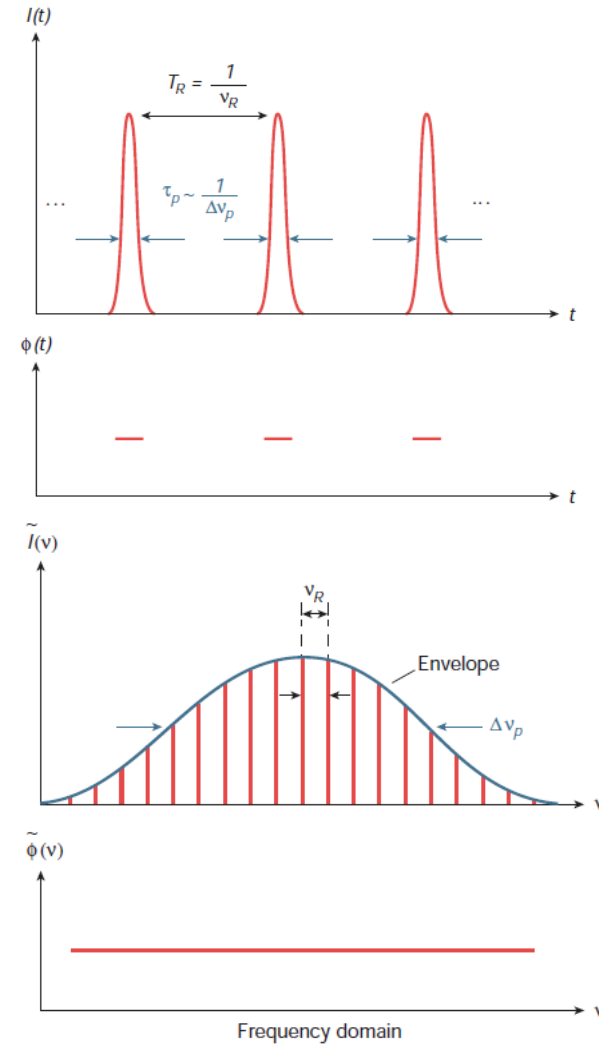
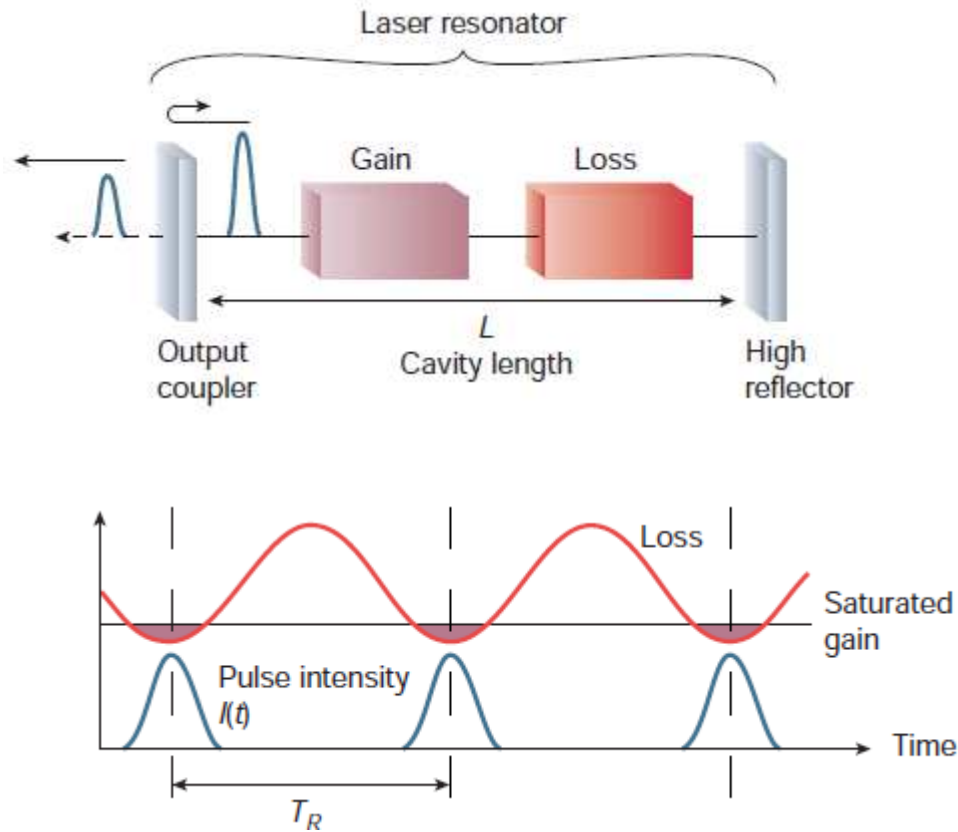
REQUIREMENTS FOR LASER SOURCE

- Low average power. Typ < 100 mW
- To avoid thermal damage.
- High peak power. Typ. > 10 kW
- To enable high number of events of simultaneous absorption of 2 photons



MODE - LOCKED LASERS

MODE-LOCKED LASERS

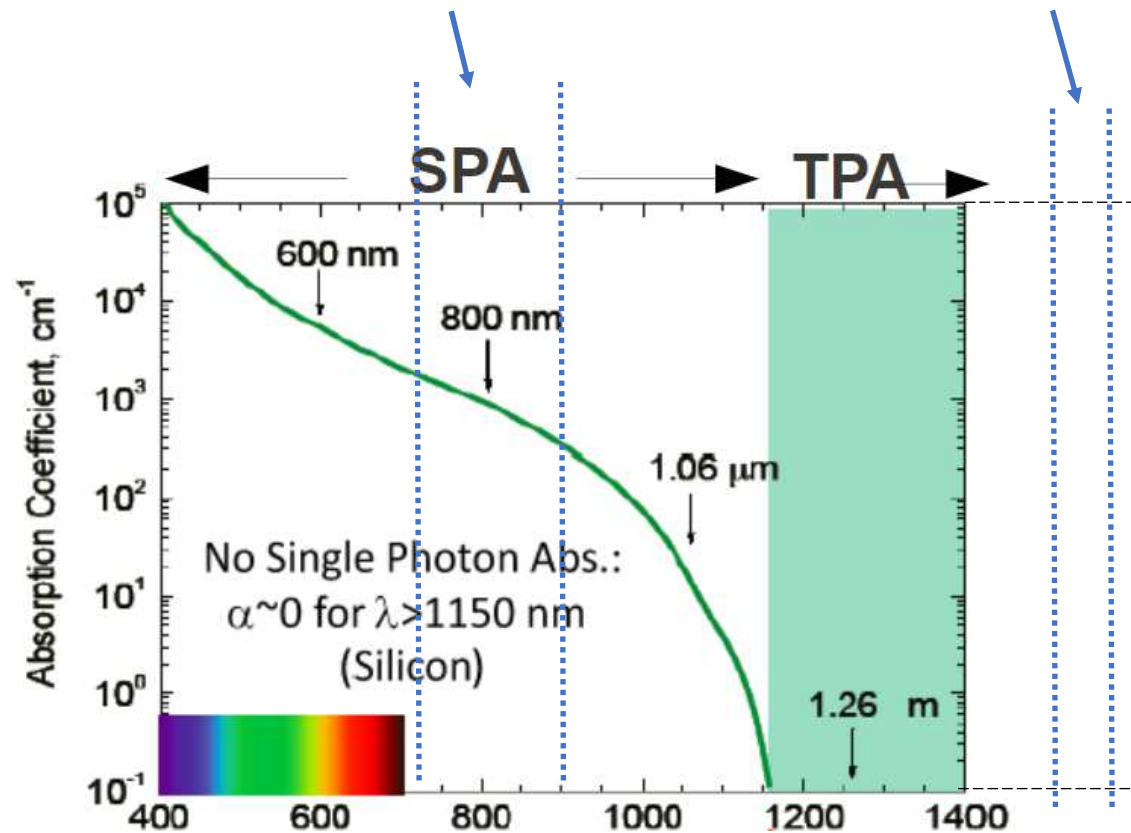


• U. Keller, *Nature*, 2003.

TPA-TCT. WHY FIBER LASERS?

Ti-Sapphire Solid State Lasers
Emission Range 700 - 900 nm

Er/ErYb - doped fiber lasers
Emission Range 1520 - 1570 nm



DRAWBACKS

- **Low pulse energy** delivered by mode-locked fiber laser oscillators. Typ < 100 pJ
- **Small diameter** of fiber cores. Typ < 10 μm. Nonlinear effects limit amplification potential



CHIRPED PULSED AMPLIFICATION

• D. McMorrow et al. 2002.

CHIRPED PULSED AMPLIFICATION

We follow a **Chirped Pulsed Amplification (CPA)** strategy. Pulses are stretched temporally, amplified and recompressed.



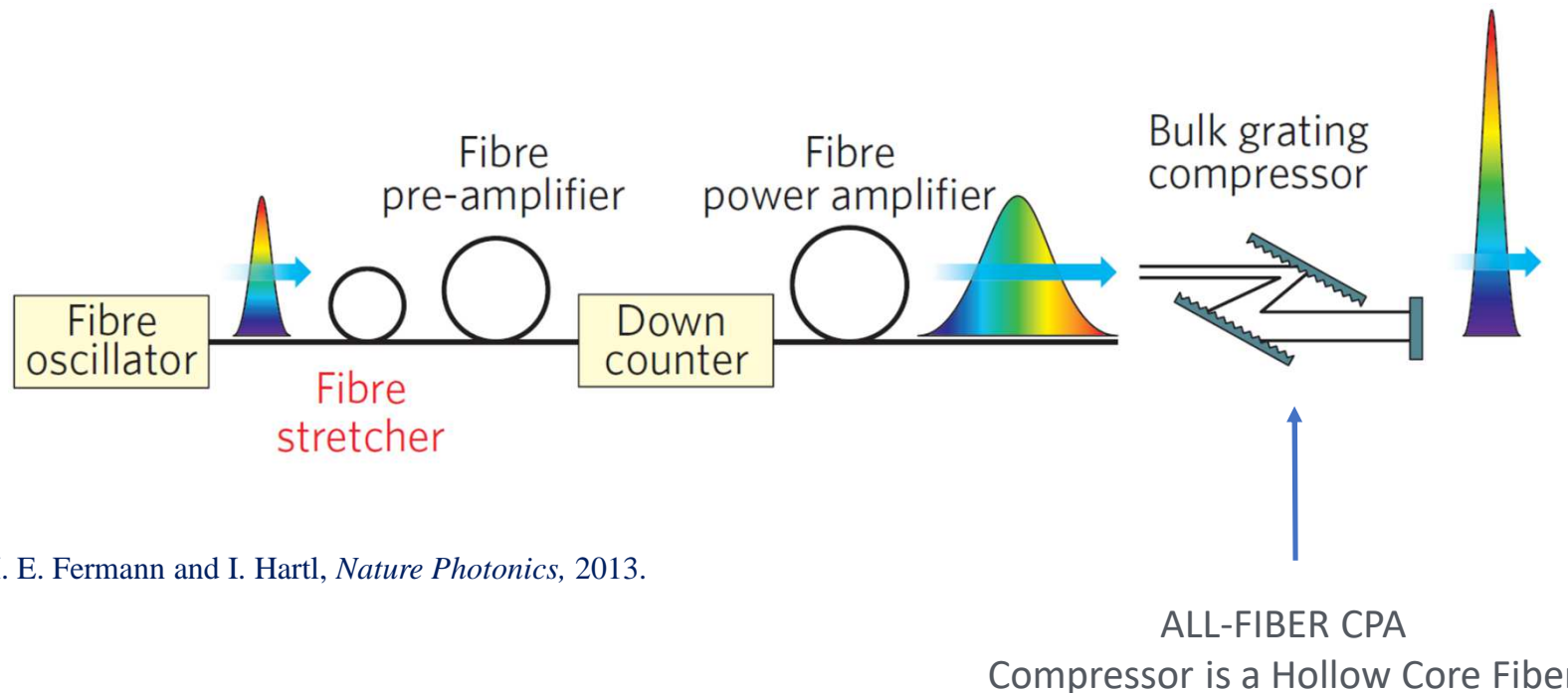
Gérard Mourou

École Polytechnique, Palaiseau, France
University of Michigan, Ann Arbor, USA

Donna Strickland

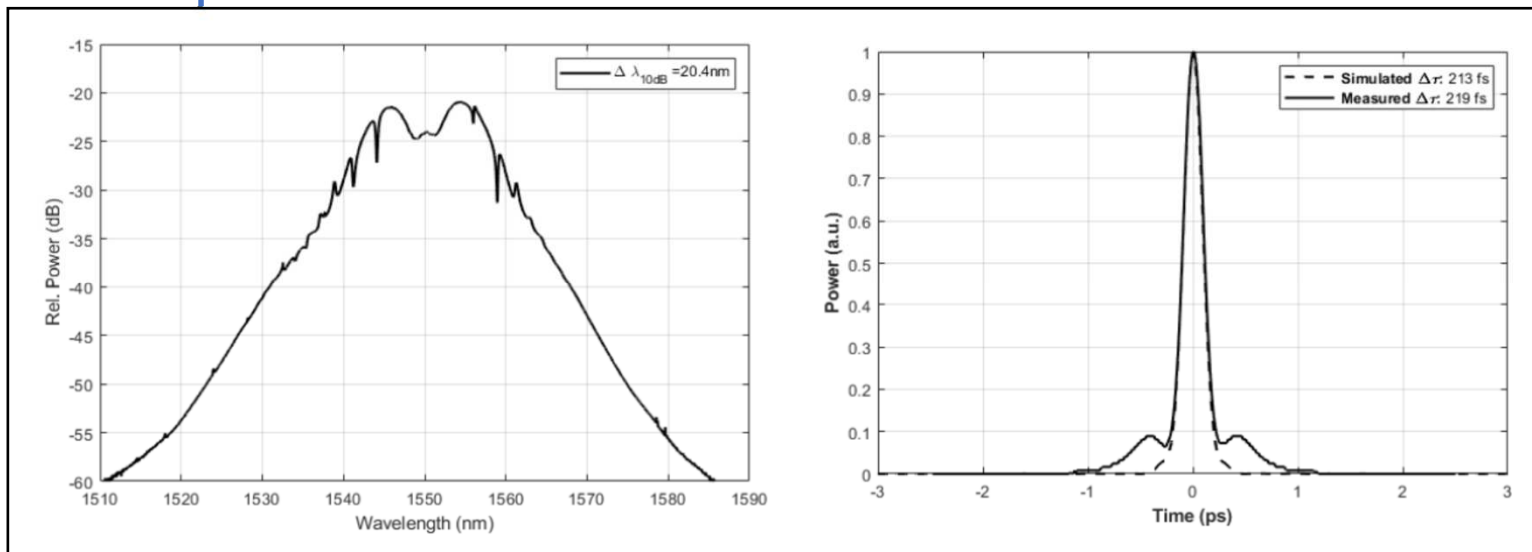
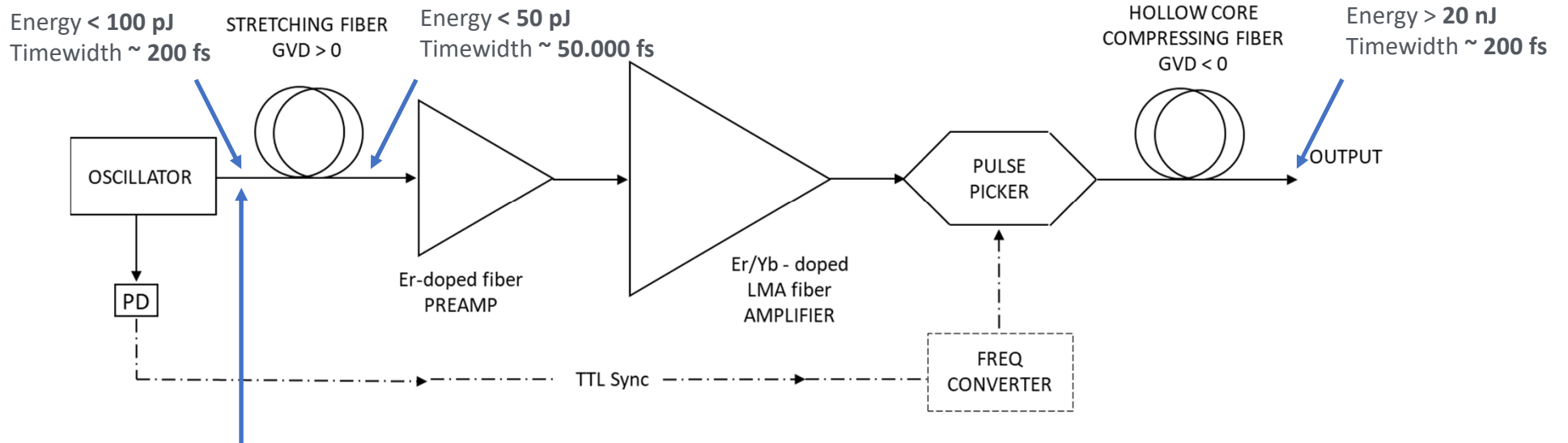
University of Waterloo, Canada

"for their method of generating high-intensity, ultra-short optical pulses"

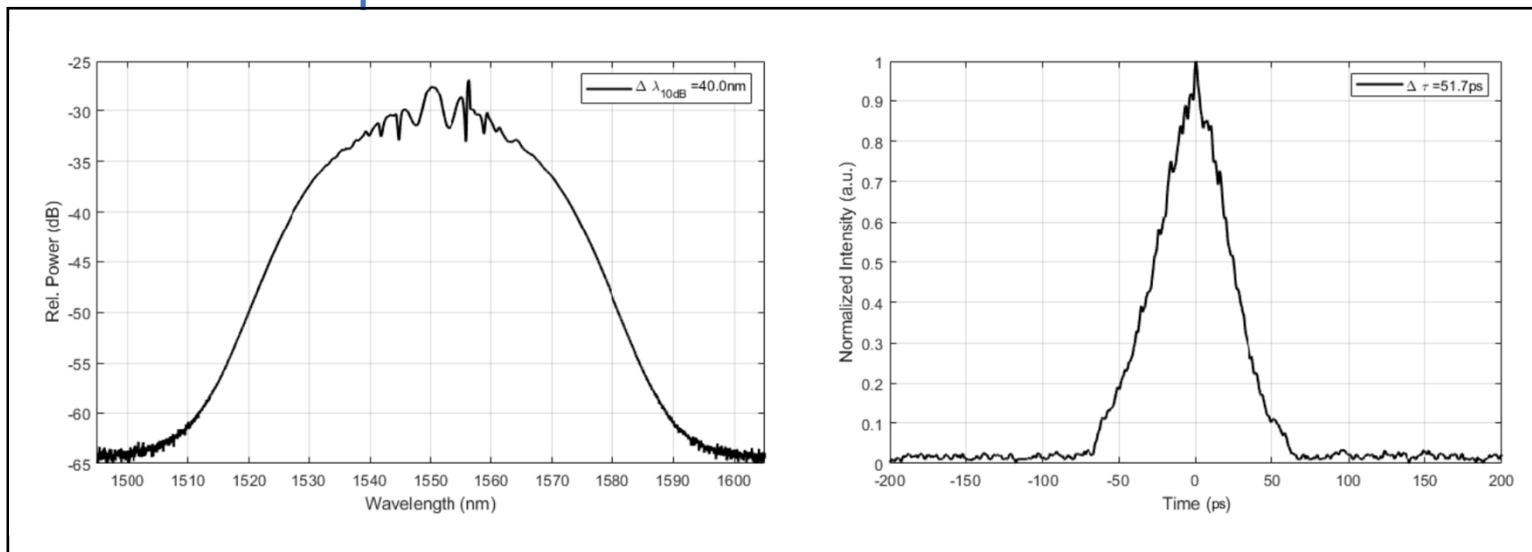
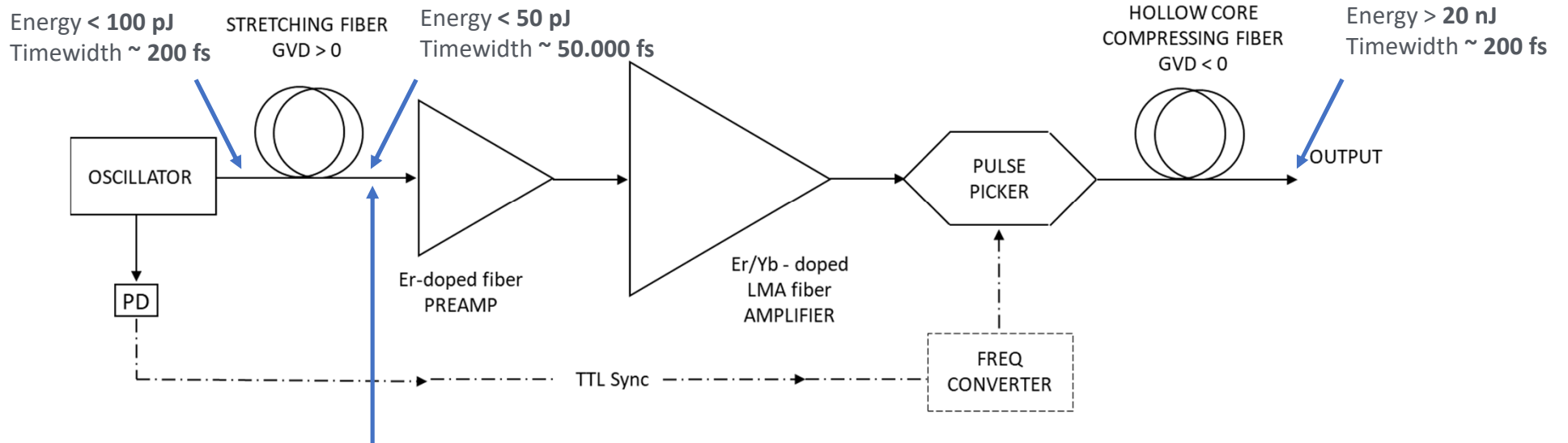


- M. E. Fermann and I. Hartl, *Nature Photonics*, 2013.

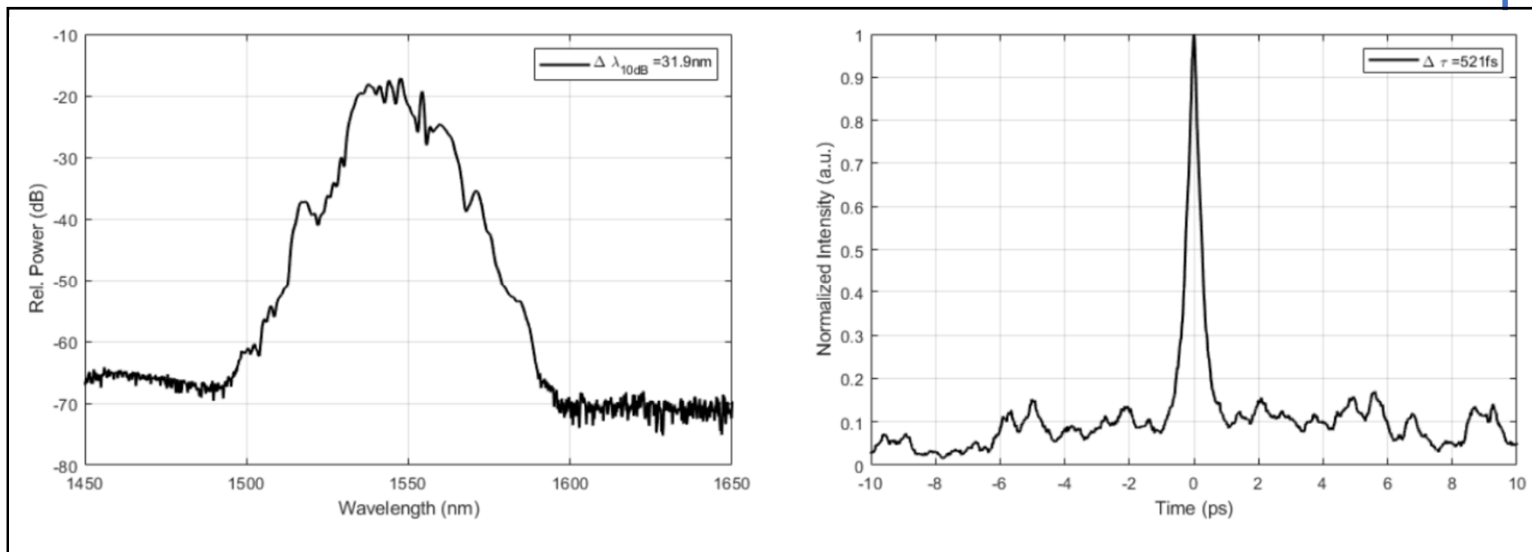
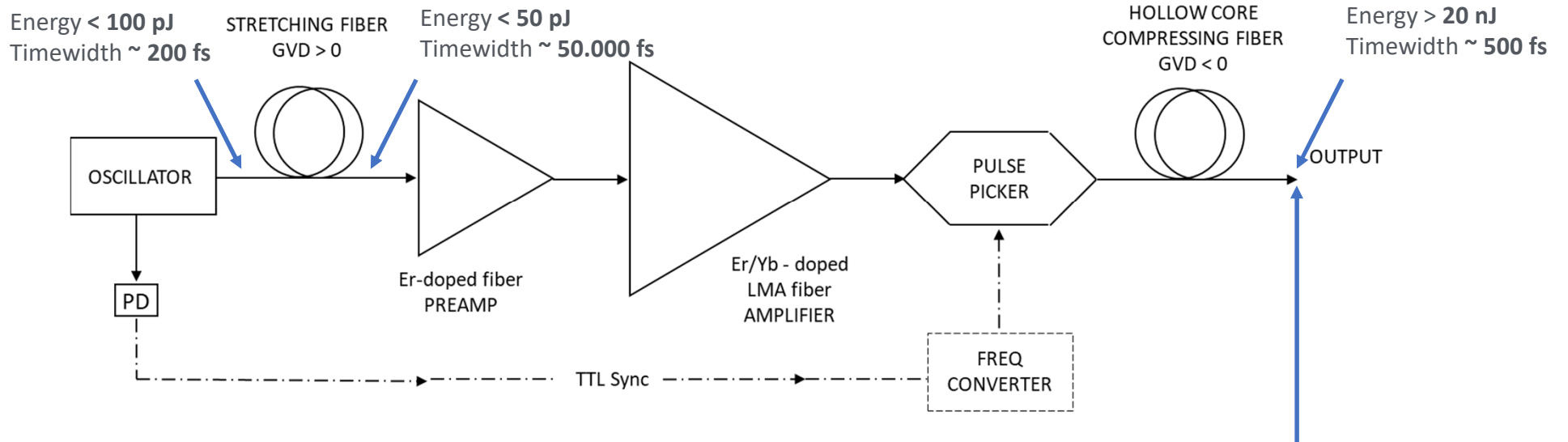
1550 NM FEMTOSECOND FIBER LASER DESIGNED FOR TPA-TCT



1550 NM FEMTOSECOND FIBER LASER DESIGNED FOR TPA-TCT



1550 NM FEMTOSECOND FIBER LASER DESIGNED FOR TPA-TCT

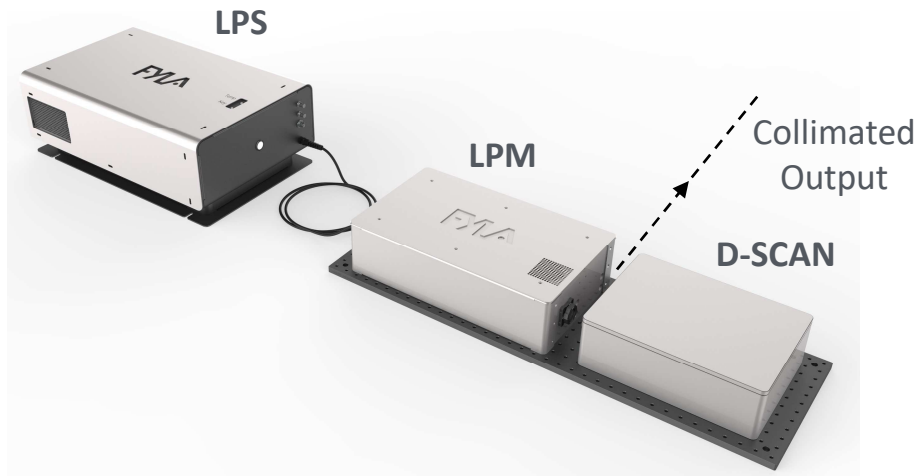


CLOSE BUT NOT
TRANSFORM
LIMITED PULSE

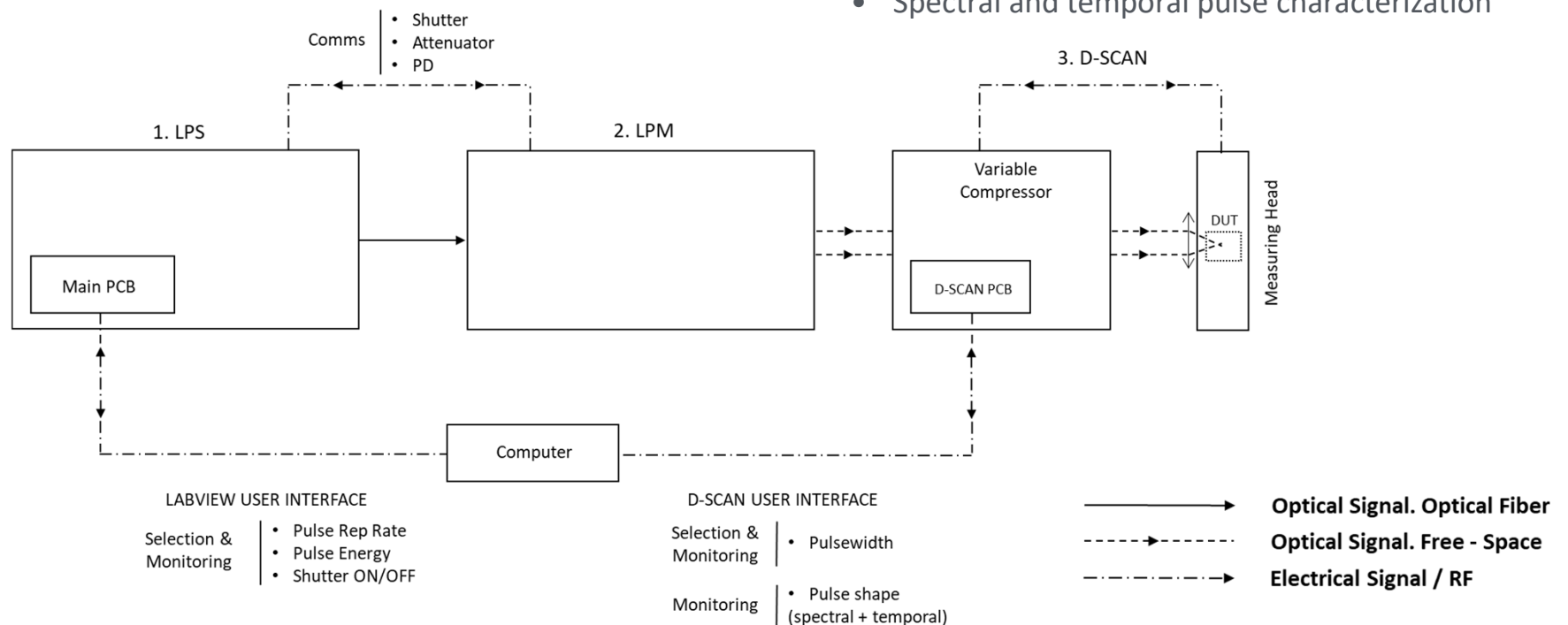
~ 100 fs

STILL TO ENHANCE
TEMPORAL
COHERENCE IN CPA
ARCHITECTURE

FIBER LASER SYSTEM DESIGNED FOR TPA-TCT



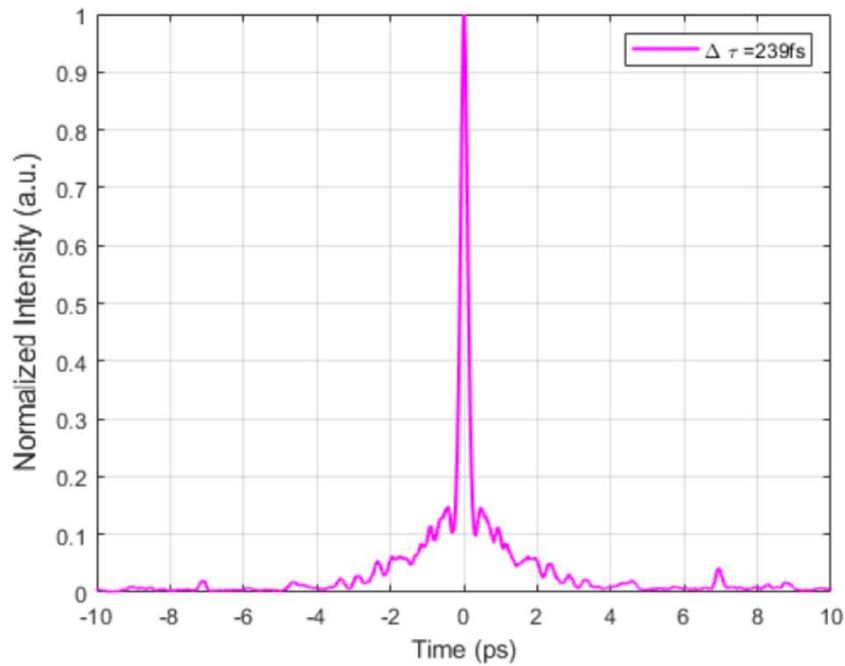
- **LPS: Laser Pulse Source**
 - All-fiber CPA femtosecond pulses generation
 - Pulse rep rate selection. **Single shot to 8 MHz**
- **LPM: Laser Pulse Management module**
 - Pulse energy modulation: **<10 pJ to > 10 nJ**
 - Synchronized shutter. **rise/fall time < 1 us**
- **D-SCAN: Dispersion scanning**
 - Pulse duration tuning: **200 fs to 500 fs** (approx)
 - Spectral and temporal pulse characterization



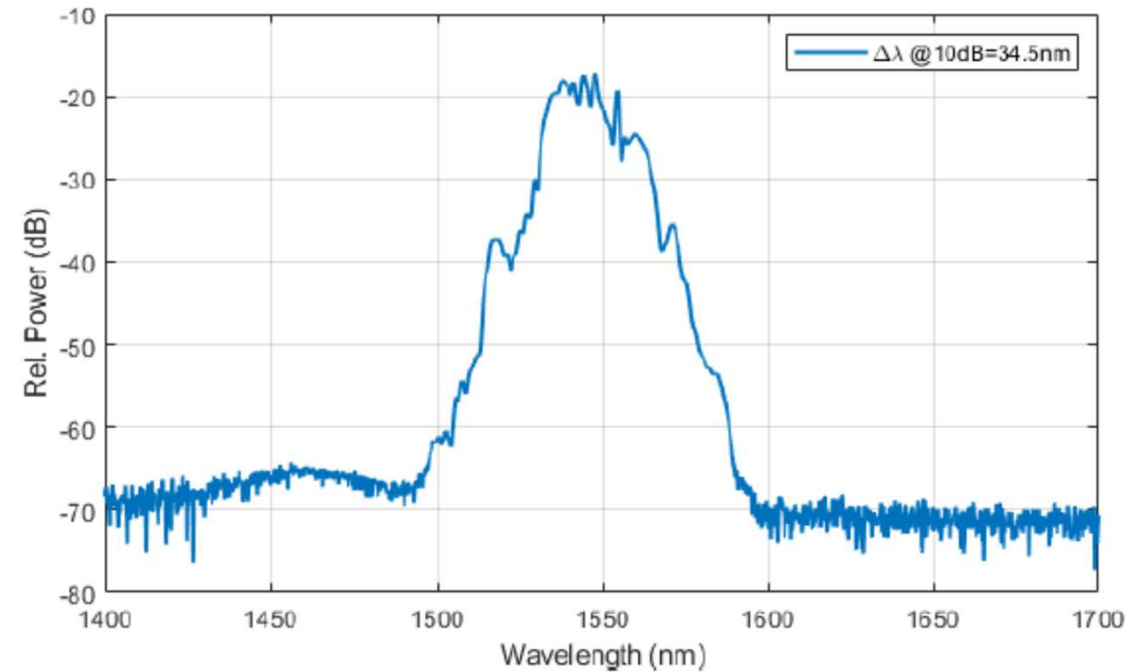
PROPERTIES AND FUNCTIONALITIES FOR TPA-TCT

OUTPUT OPTICAL PROPERTIES

Autocorrelation



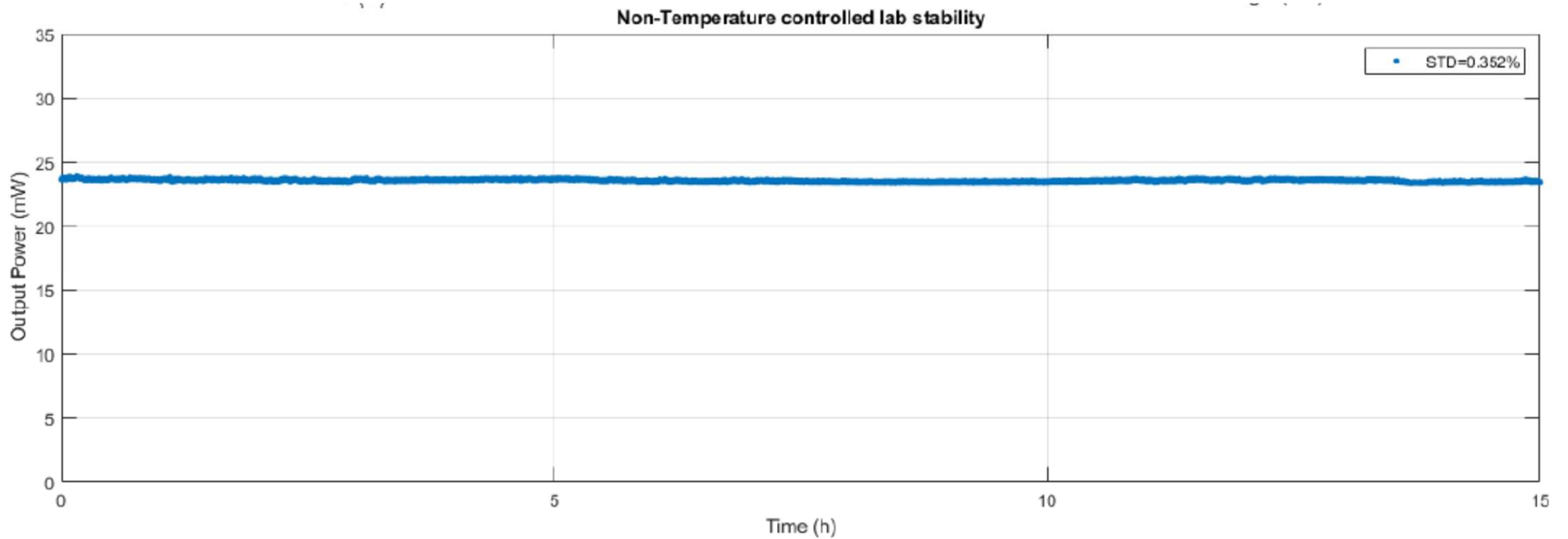
Optical spectrum





PROPERTIES AND FUNCTIONALITIES FOR TPA-TCT

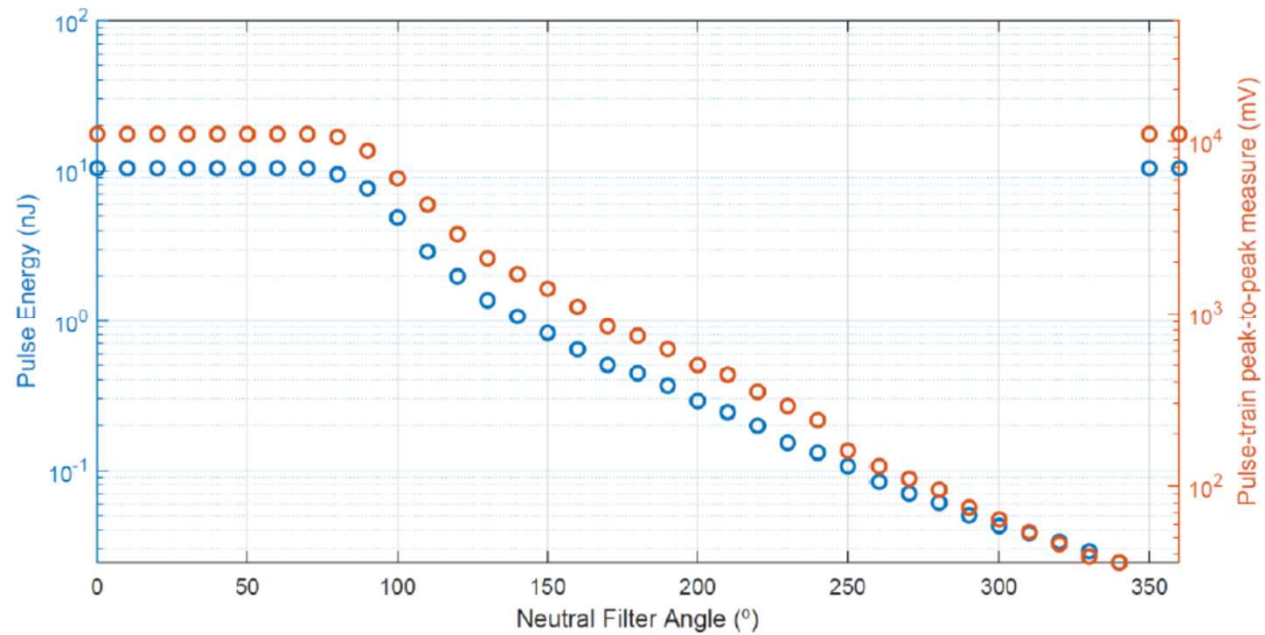
STABILITY



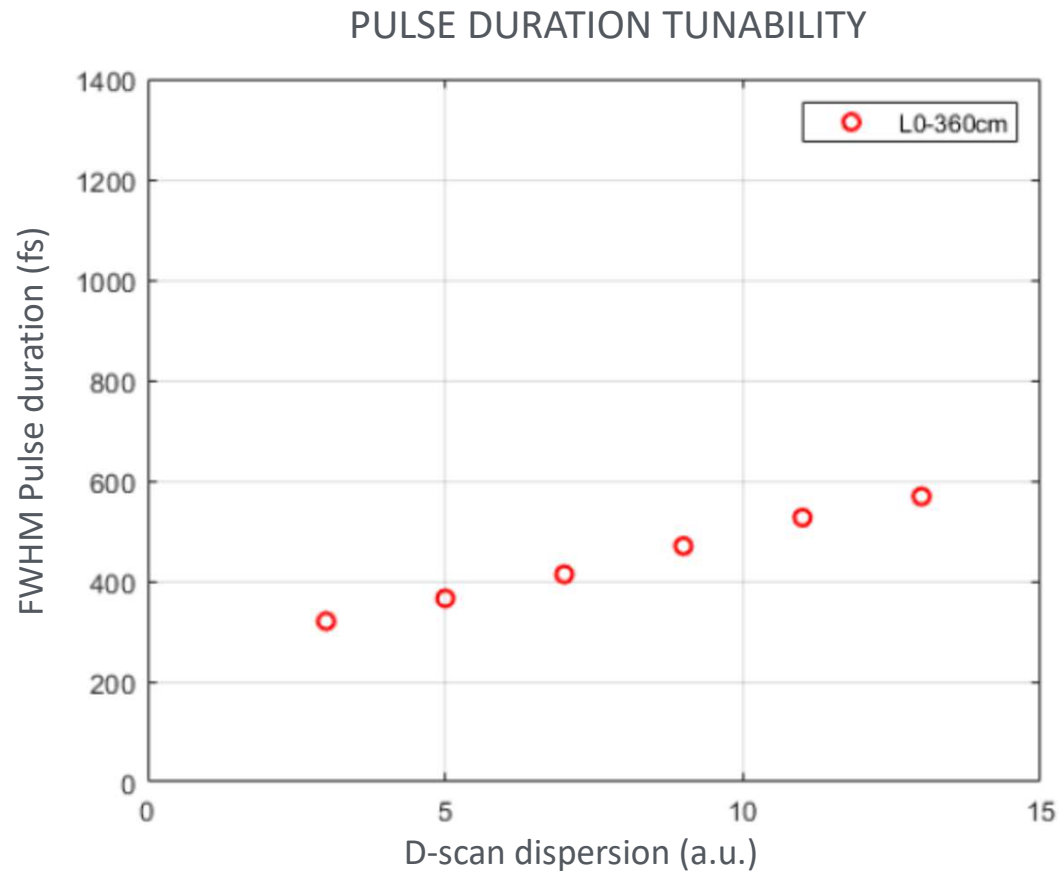
Output average power at 4 MHz pulse rep rate

PROPERTIES AND FUNCTIONALITIES FOR TPA-TCT

PULSE ENERGY SELECTION

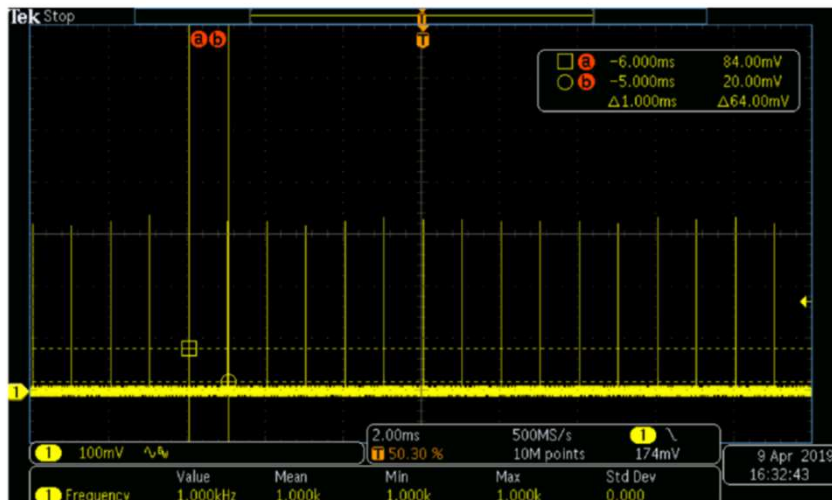


PROPERTIES AND FUNCTIONALITIES FOR TPA-TCT

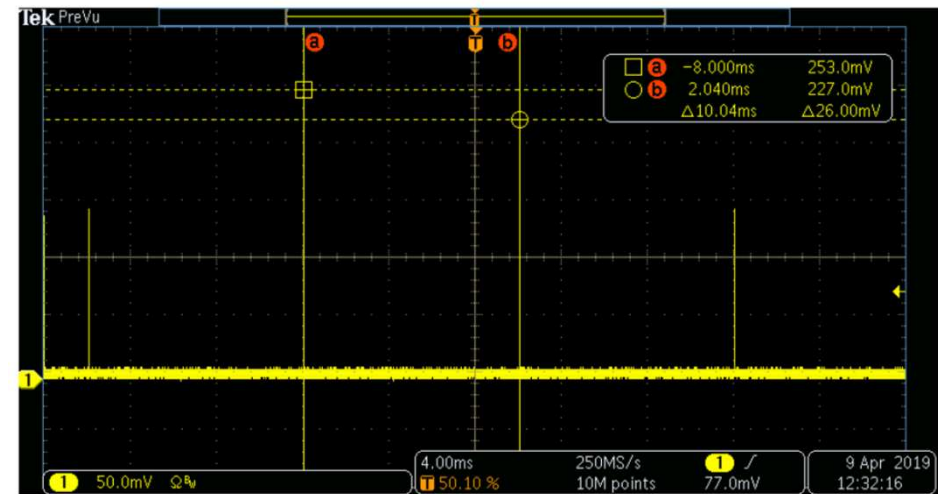


PROPERTIES AND FUNCTIONALITIES FOR TPA-TCT

PULSE REP RATE SELECTION



1 KHz



100 Hz

PROPERTIES AND FUNCTIONALITIES FOR TPA-TCT

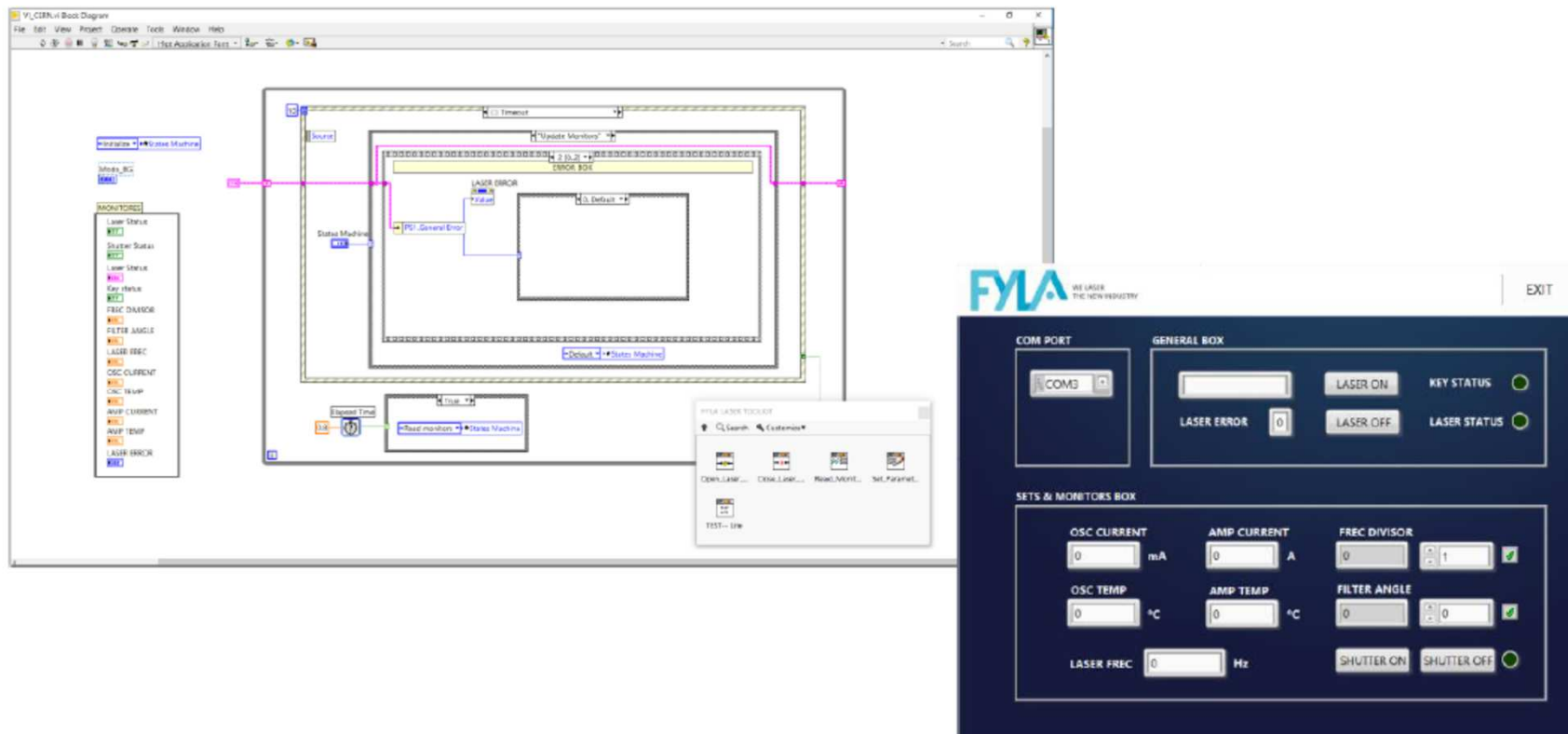
SYNCHRONIZED OUTPUT COMMUTING



PRR 1000 Hz; SHUTTER FALL TIME < 1 us

PROPERTIES AND FUNCTIONALITIES FOR TPA-TCT

LABVIEW-BASED CONTROL OF FUNCTIONALITIES





CONCLUSIONS

- A **1550 nm femtosecond fiber laser system** with properties and functionalities especially designed for the needs of the **TPA-TCT** has been developed.
- The femtosecond fiber laser source is based in an **All-fiber Chirped Pulse Amplification** architecture that provides **excellent robustness and stability** to the output pulsed signal of the system.
- **The system has been tested successfully at CERN** for the generation of localized transient currents in semiconductor detectors.
- Work to obtain shorter pulses (<100 fs) is ongoing.
- Further integration work with the full TPA-TCT system is envisaged.



THANKS FOR YOUR ATTENTION

QUESTIONS?