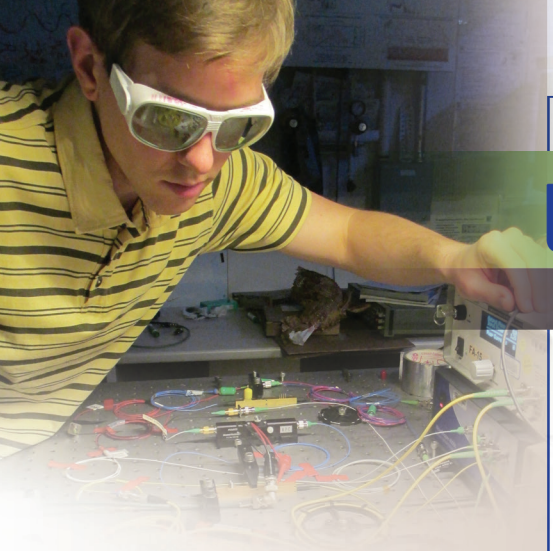
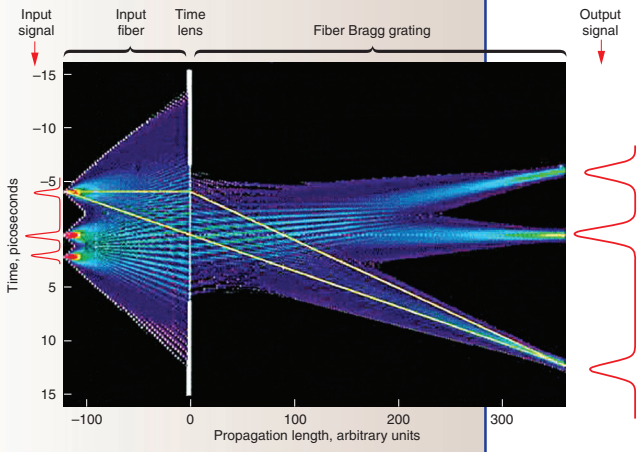


Ultrafast Optics and Photonics

Lawrence Livermore National Laboratory

LLNL is a world leader in developing temporal imaging, ultrafast chipscale photonics, radiation-to-optical transcoders, and high-speed radio frequency (RF) instrumentation technologies. Our ultrafast optical and electronics systems staff is engaged in developing advanced techniques for generating, controlling, transcoding, and recording ultrafast signals in order to support a broad spectrum of Laboratory missions, including stockpile stewardship science, the National Ignition Facility (NIF), and Department of Defense applications.

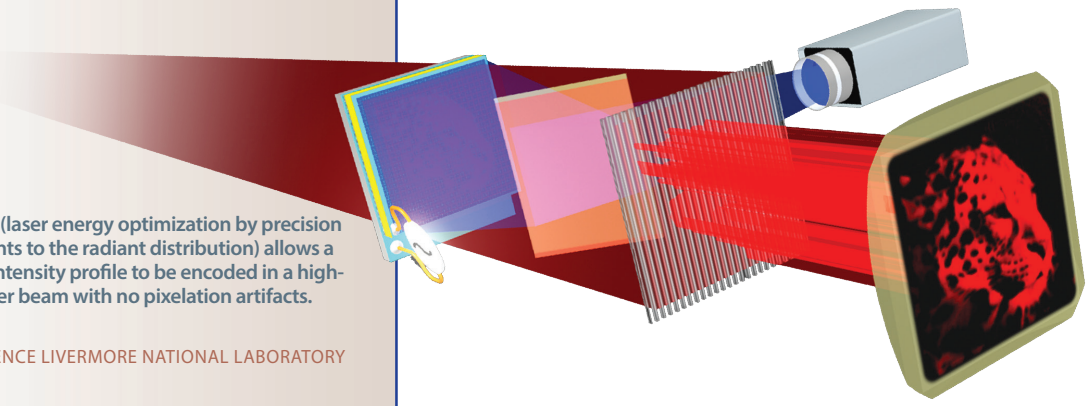


A false-color image shows three pulses propagating through a temporal imaging system with a magnification of three times. Color here represents intensity or brightness, with red being the brightest. The simulation shows how three optical pulses occurring in a 6-picosecond time frame can be "time magnified" so that, at the output, they occur over 18 picoseconds.

Supporting the cutting-edge science performed at the Laboratory requires that we build systems with performance well beyond the limits of commercially available optics and electronics technologies. Such systems include ultrafast lasers and diagnostics for optical phenomena with timescales much less than 1 nanosecond, or high-speed RF electronics operating at frequencies far above 1 gigahertz.

Example Projects

- Developed the Laser SHIELD (screening at high-throughput to identify energetic laser distortion), which identifies nonconforming and potentially damaging energetic laser pulses at the NIF using a real-time 34-gigahertz oscilloscope. (R&D100 winner, 2013)
- Developed the LEOPARD arbitrary beam-shaping system for fusion-class lasers that precisely adjusts a laser beam's radiant distribution or intensity profile, enabling the correction of residual imperfections in a beam. (R&D100 winner, 2012)
- Developed the serrated light illumination for deflection-encoded recording (SLIDER), a solid-state, photon-deflecting streak camera capable of recording optical signals on picosecond (trillionth of a second) timescales. (R&D100 winner, 2011)
- Developed the FemtoScope, a "time microscope" that can be attached to the front end of a conventional recording instrument such as an oscilloscope or streak camera to dramatically improve its performance by ultrafast processing of waveforms (hundreds of femtoseconds). (R&D100 winner, 2009)



LEOPARD (laser energy optimization by precision adjustments to the radiant distribution) allows a detailed intensity profile to be encoded in a high-power laser beam with no pixelation artifacts.

Expertise

Novel diagnostic development capabilities:

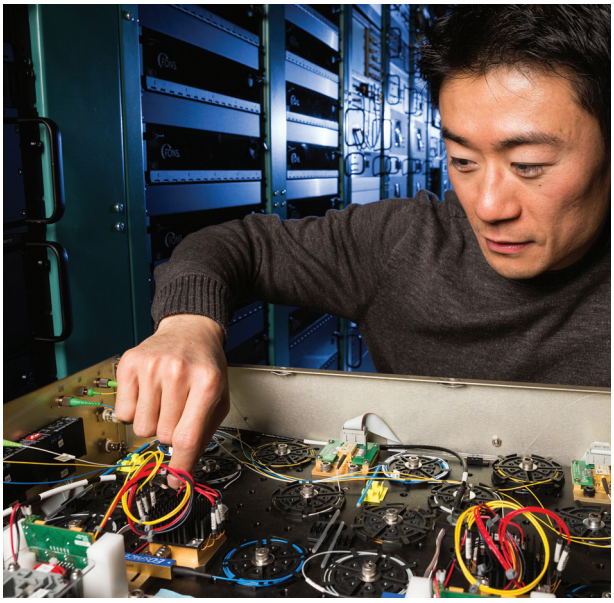
- Temporal imaging and temporal-spectral Fourier transformation
- All-optical, chipscale nonlinear optics in semiconductors for deflection and sampling
- X-ray-to-optical format transcoding
- Optical-Electronic-Optical (OEO) wavelength conversion
- Optical arbitrary waveform generation and detection
- RF photonic systems and processors

System integration and controls:

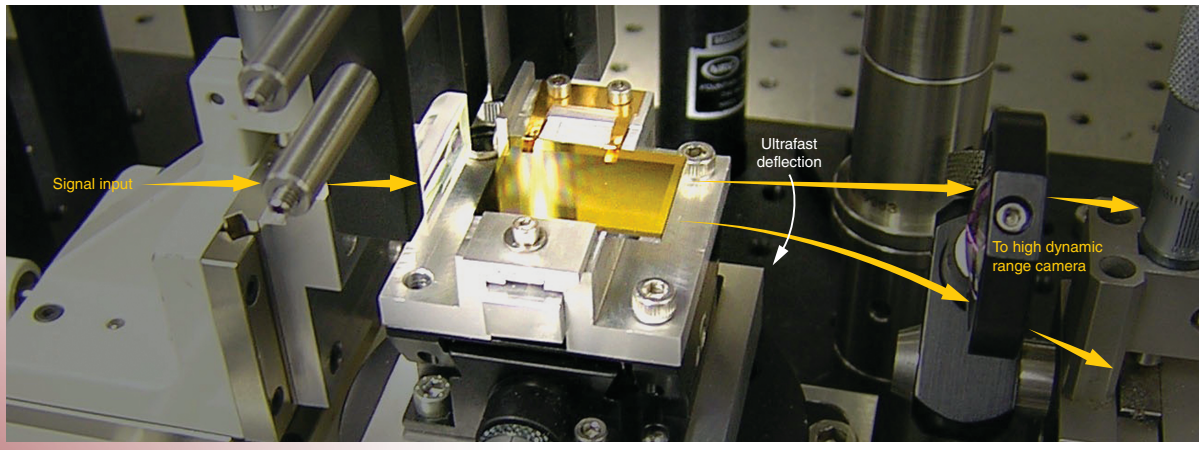
- Beam- and pulse-shaping controls on injection laser systems for NIF and the Advanced Radiography Capability (ARC)
- Beam-steering control on accelerators

Technologies

- High-frame-rate multichannel microscopy
- Timestretch recording
- RF-Photonic signal processing
- Novel fiber amplifiers
- High-speed RF electronics and photonics
- Chipscale nonlinear photonics
- Optical metrology
- Beam and pulse shaping control
- Temporal Fourier transformation



In the past, operators needed up to 12 hours to manually screen 48 critical checkpoints for harmful laser pulses at the National Ignition Facility. With Laser SHIELD, the screening can be done in less than 1 second and at the push of a button.



Signals to be recorded propagate from left to right in a thin waveguide layer at the top of the SLIDER (serrated light illumination for deflection-encoded recording system) deflector.

Capability Leader

John Heebner **925-422-5474** **heebner1@llnl.gov**

John leads the Ultrafast Optical and Electronics Systems Group in the Materials Engineering Division. He has a background in nonlinear/ultrafast optics, integrated optics, optical microresonators, laser beam shaping and pulse shaping. He led the qualification of the NIF Injection laser system, including the LEOPARD upgrade; designed the Advanced Radiographic Capability (ARC) Injection Laser System; and demonstrated SLIDER, the world's fastest light deflector. John earned his Ph.D. in Optics from the University of Rochester in Rochester, NY. He has been awarded four R&D 100 awards, three patents, and is the author of over 30 publications and a textbook.

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