Advanced Solid State Lasers for Space Tracking

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EOS Space Systems

SERC

Key requirements for advanced solid state lasers - application specific

Lasers for space applications including tracking and ranging require:

- Beam quality
- Efficiency
- Reliability
- Robustness
- Automation
- Special mode structure

2 types of solid state lasers

- Pico-second pulse width system for Satellite Laser Ranging (SLR)

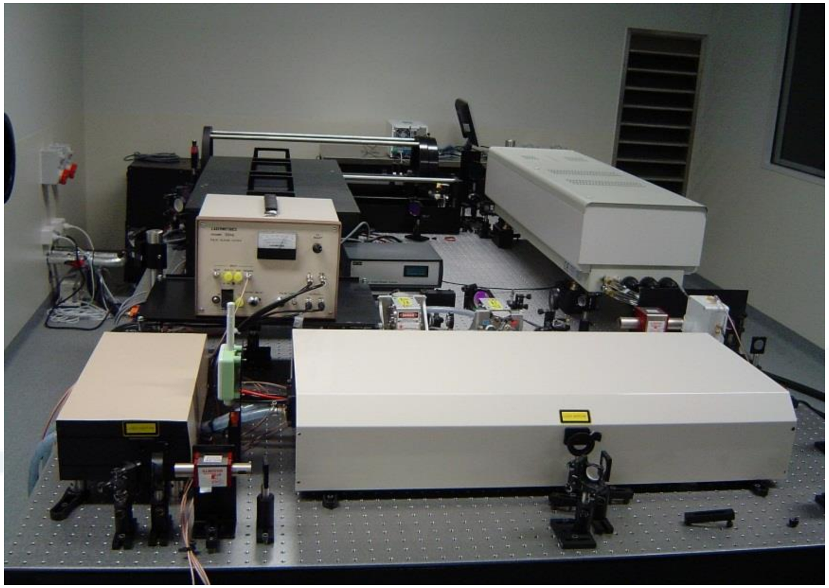
- Nano-second pulse width system for space debris tracking

3 Generations of pico-second pulse width laser systems developed

Generation-1: 30 ps pulse width, combination of diode and flashlamp pumping

Generation-2: < 20 ps pulse width, completely diode pumping, ring-cavity regenerative amplifier

Generation-3: < 12 ps pulse width, completely diode pumping, standing-wave cavity regenerative amplifier, modular design with remote control and monitoring capability



G-3 diode pumped pico-second pulse width system for SLR

- Consisting a mode-locked laser oscillator, a regenerative amplifier, a power amplifier and a high efficiency (>70%) SHG
- Oscillator passively mode-locked using Semi-Conductor Saturable Absorption Mirror, developed by EOS and ANU
- Regenerative amplifier with a standing-wave cavity offers excellent stability
- Modular design offers flexibility
- Remote control and monitoring capability
- Can be configured to 1 kHz to support kHz ranging with Module - 1 when other conditions allow
- Can be upgraded to eyesafe wavelength @ 1.57 μm by implementing OPG and OPA

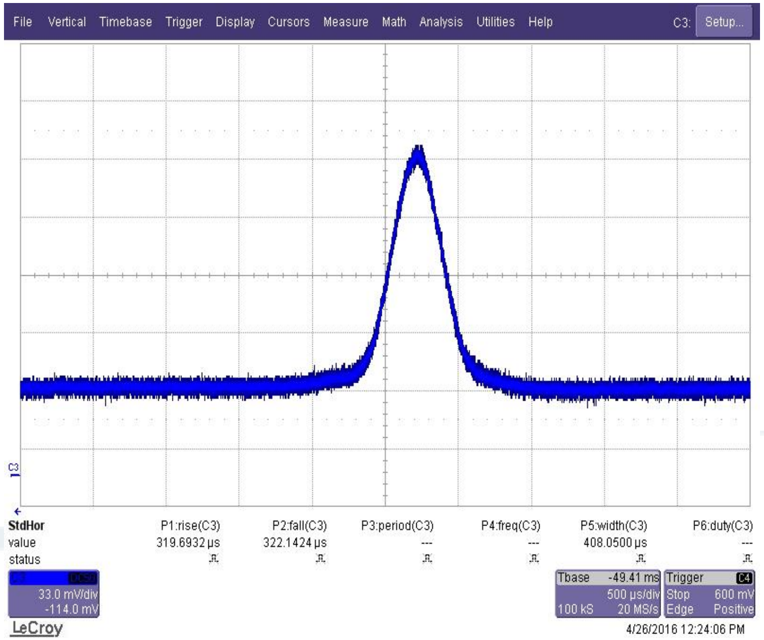
Key specifications achieved for pico-second pulse width system

Wavelength	532 nm
Pulse energy	15 mJ (nominal) 20 mJ (maximum)
Repetition rate	60 Hz
Energy stability	1.1%
Pulse width	< 12 ps
Beam quality	M^2: 1.786
Beam divergence	0.121 mR (full angle)
Beam pointing stability	Better than 0.02 mR

Pulse width measurement

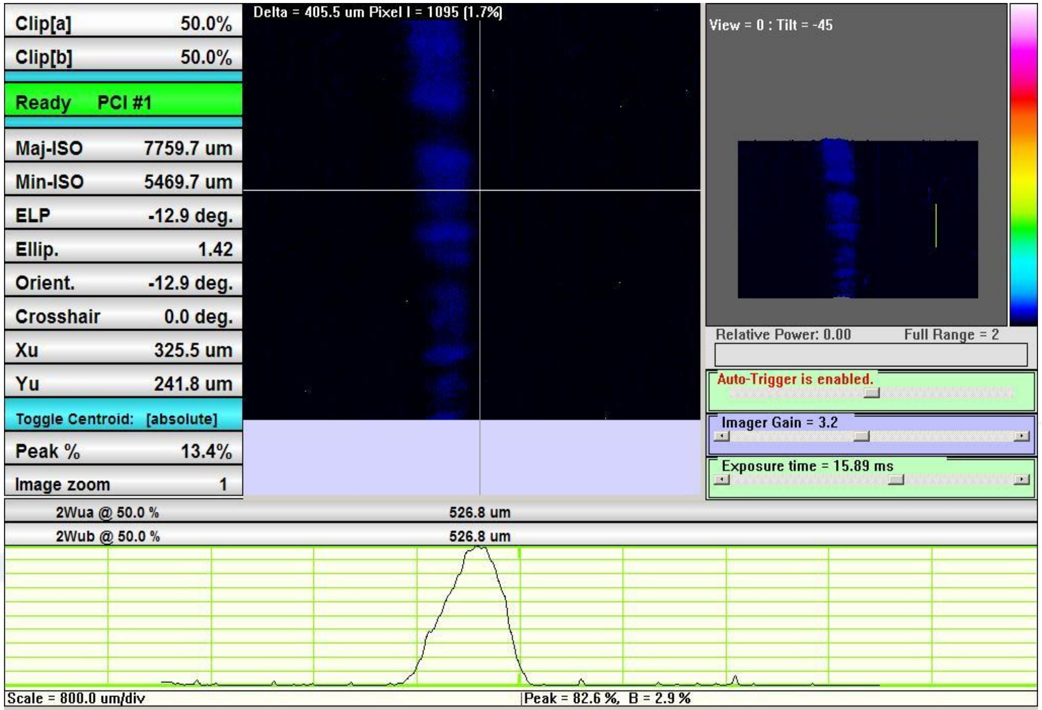
Measured pulse width (FWHM) = 0.408 ms* 32 ps/ms*0.707 = 9.2 ps

Calibration factor of autocorrelator = 32 ps/ms),
assuming Gaussian pulse shape



Pulse width broadening after amplification processes?

Streak camera trace of power amplifier output

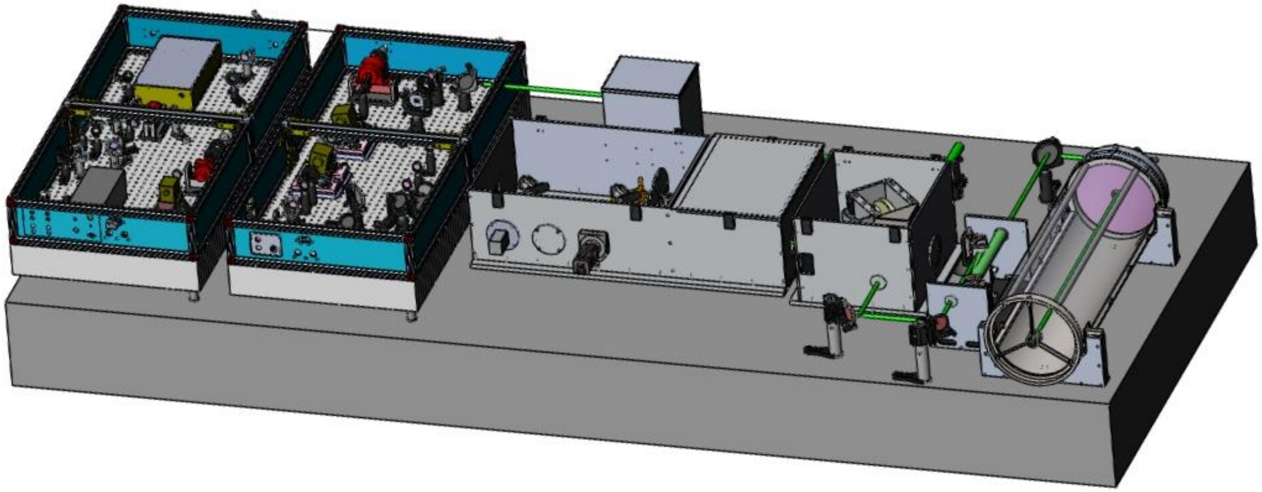


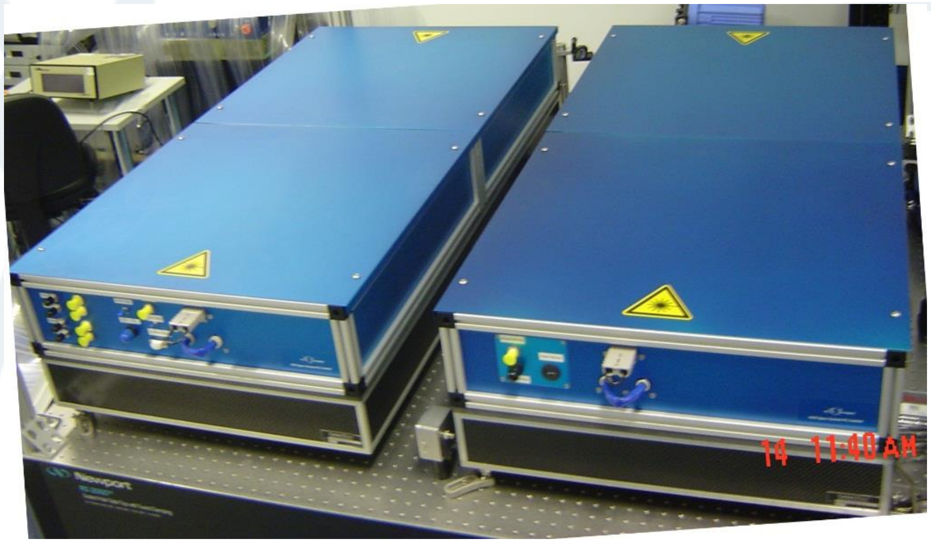
Measured pulse width (FWHM)
= 0.5268mm * 20ps/mm
= 10.54 ps

Calibration factor 20ps/mm

For a pulse width around 10 ps the pulse width broadening is very minor, < 20% after the amplification processes, including regenerative amplifier and power amplifier

G3 pico-second system designed and developed





EOS high energy laser systems

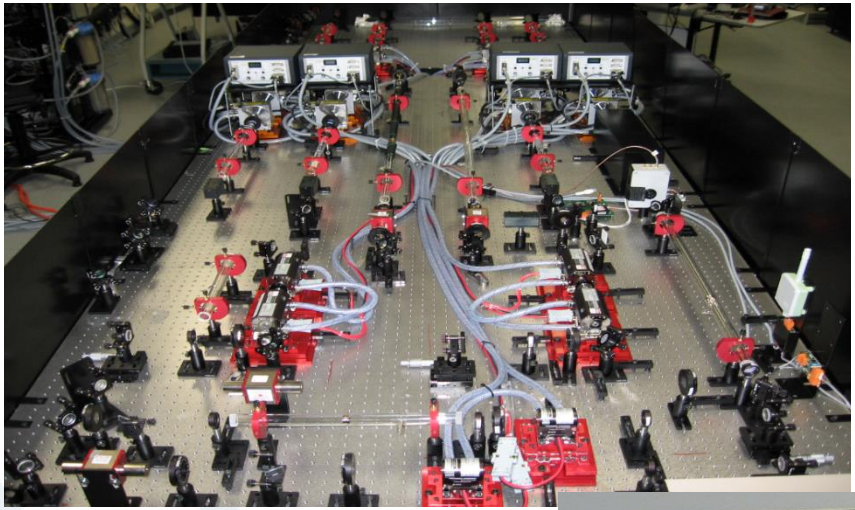
It is based on a Master single frequency Oscillator, followed by multi-stage Pre-Amplifiers/Power Amplifiers (MOPA) architecture

Unique technologies developed by EOS:

- High reliability, mode-hopping free pulsed single frequency oscillator
- Sealed Phase Conjugate Mirror or SBS cell based on Stimulated Brillouin Scattering effect
- Imaging relay system with spatial filters in permanently sealed vacuum cells
- Ultra-stable mechanical mounts
- Fully automated and 24/7 operation

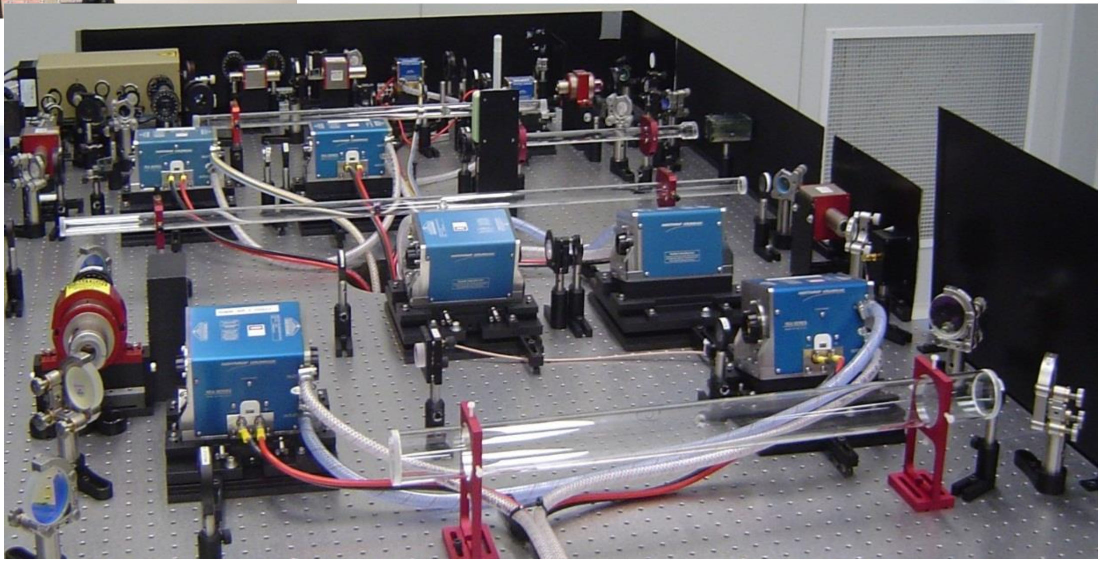
2 Generations of high energy laser systems developed

EOS



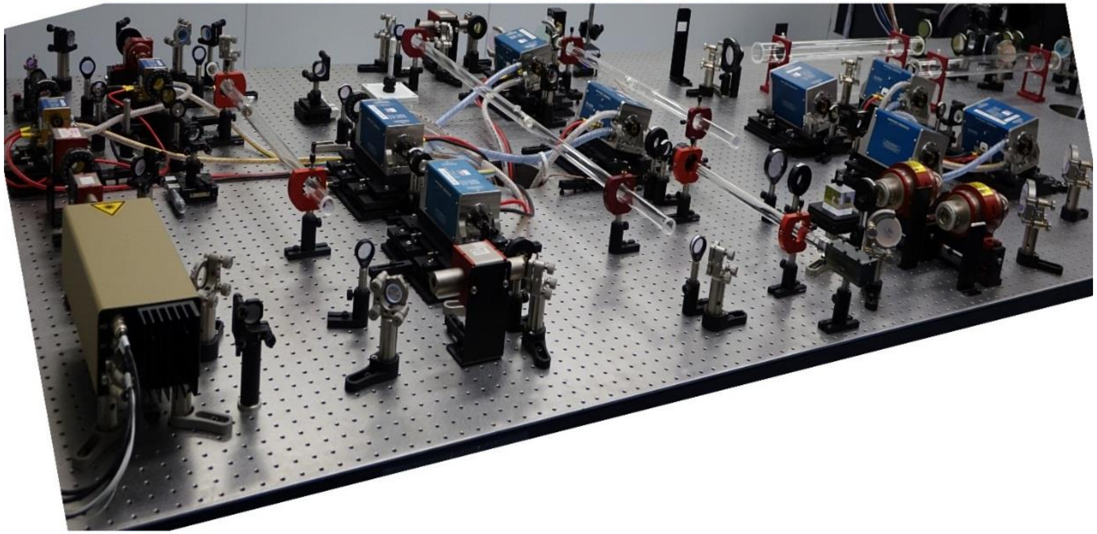
300 W system

kW class system

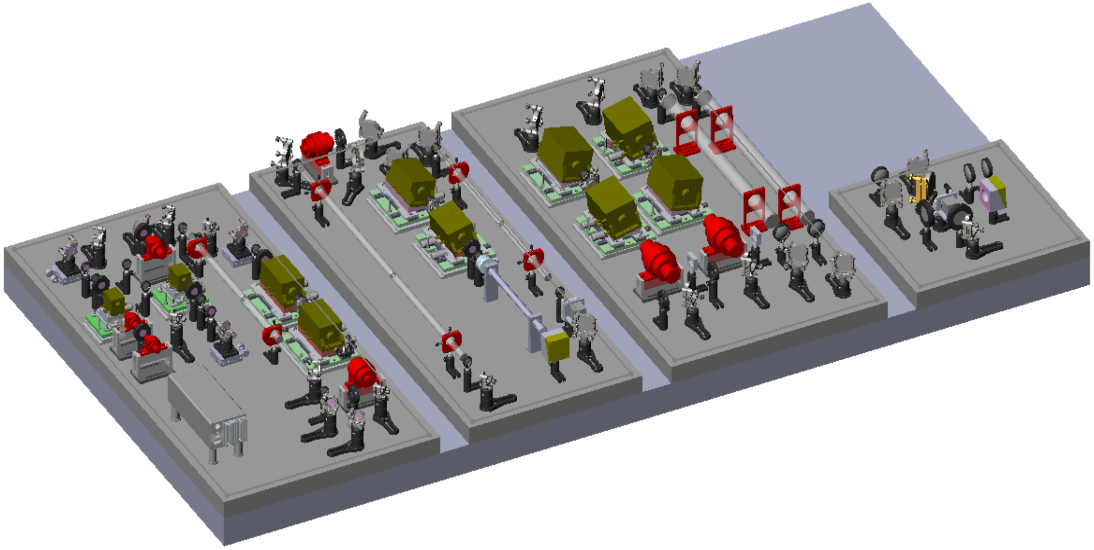


The footprint of the kW class system is ~1/3 of the 1st generation 300 W system

2 versions of kilo-watt class high energy laser designed and developed



Tabletop version

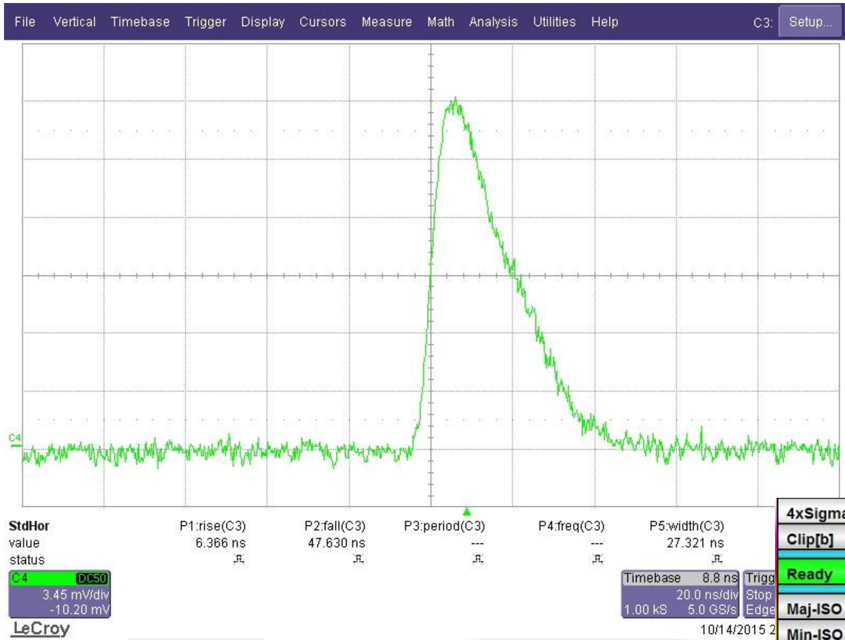


Modular version

Key specifications achieved

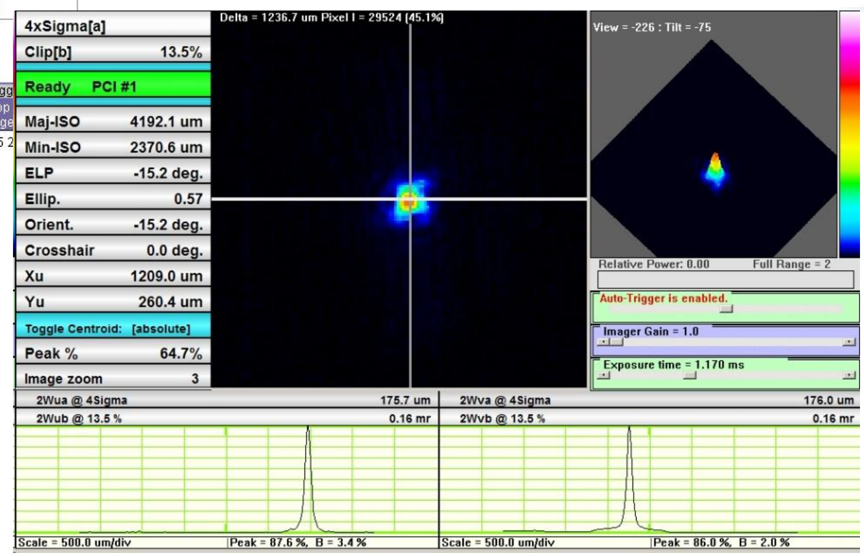
Pulse energy	4.7 J
Repetition rate	100 - 200 Hz
Average power	800 W (@170 Hz)
Pulse width	6 - 20 ns
Beam quality	M^2-X: 2.77 M^2-Y: 4.24
Beam pointing stability	0.7 arcsecond

System outputs



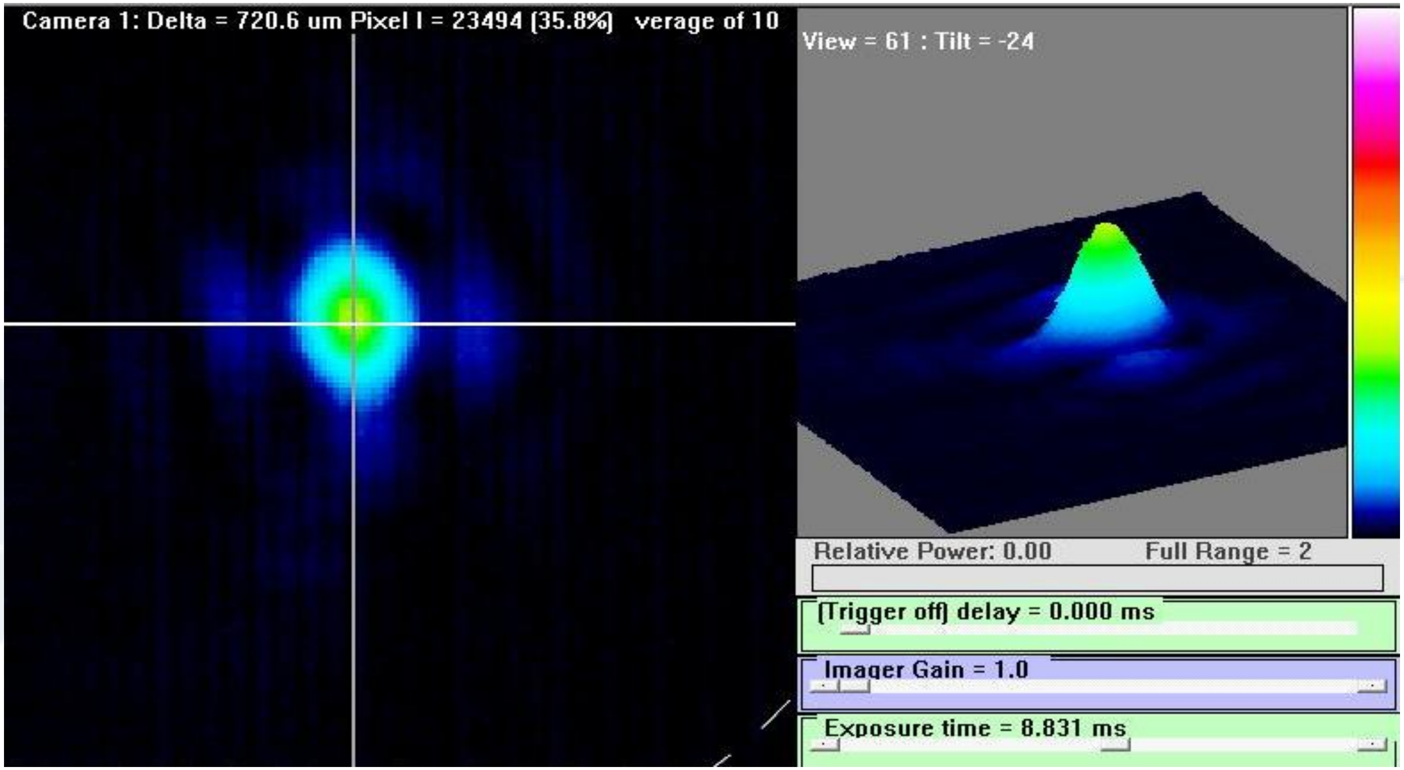
Pulse width and shape

Beam divergence and pointing stability



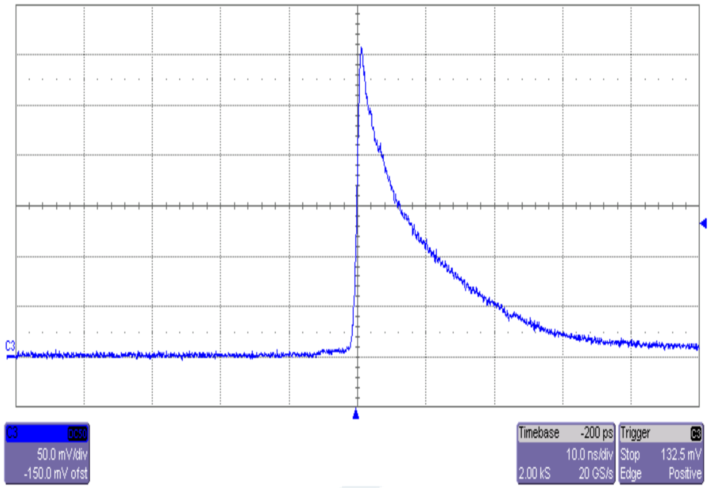
System output – very good beam quality

M^2-X: 2.77
M^2-Y: 4.24

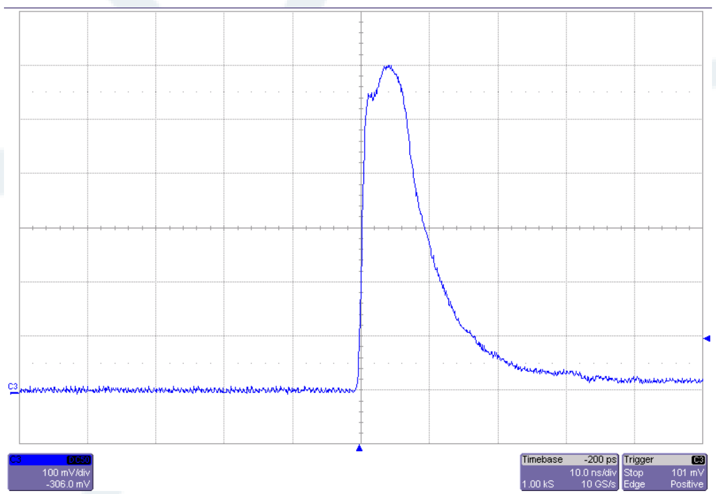


Beam Profile at 4.7 J and 170 Hz

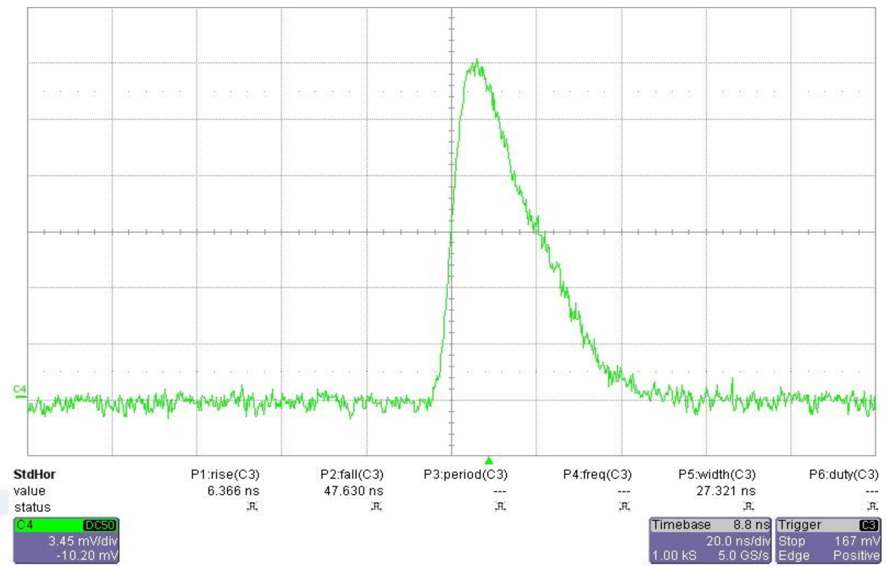
Different pulse widths can be achieved



6 ns (FWHM) Pulse Width



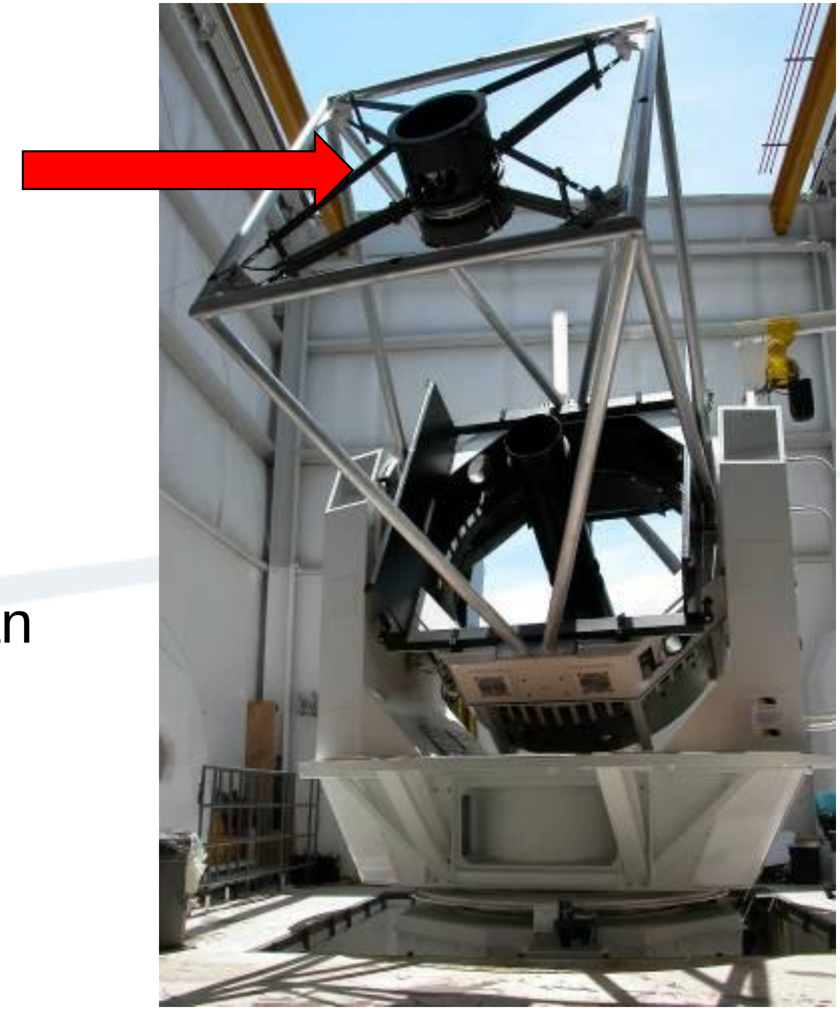
9 ns (FWHM) Pulse Width



20 ns (FWHM) Pulse Width

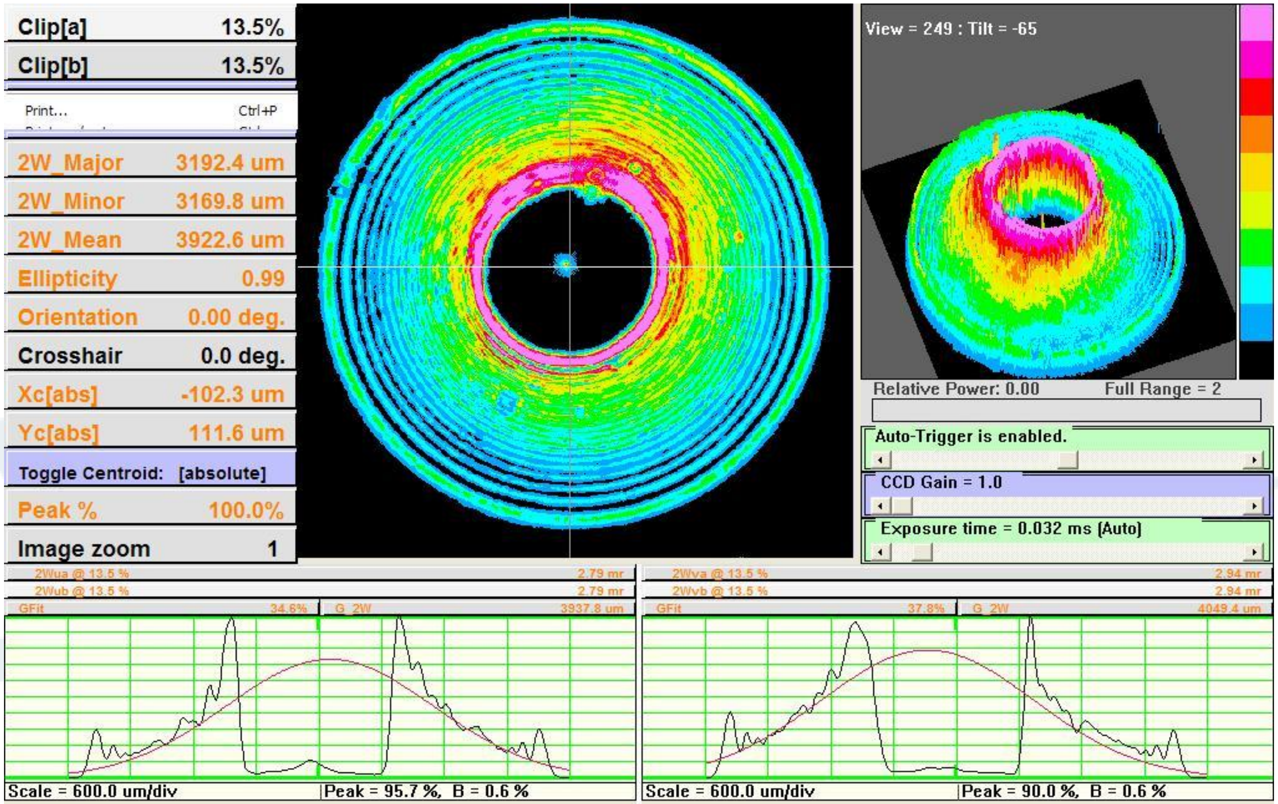
Special beam profiles for space ranging and tracking applications

The laser beam is launched into space through telescope, the secondary mirror obscures the laser beam



- Loss of energy
- A lot of energy is reflected back, that can cause damage to the system

Donut beam for escaping central obscuration



The size of the central hole can be controlled by manipulating several parameters of the beam shaping optics assembly

All the design objectives and specifications have been met and both types of systems have been in fully automated operations for a number of years with excellent performance reliability

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