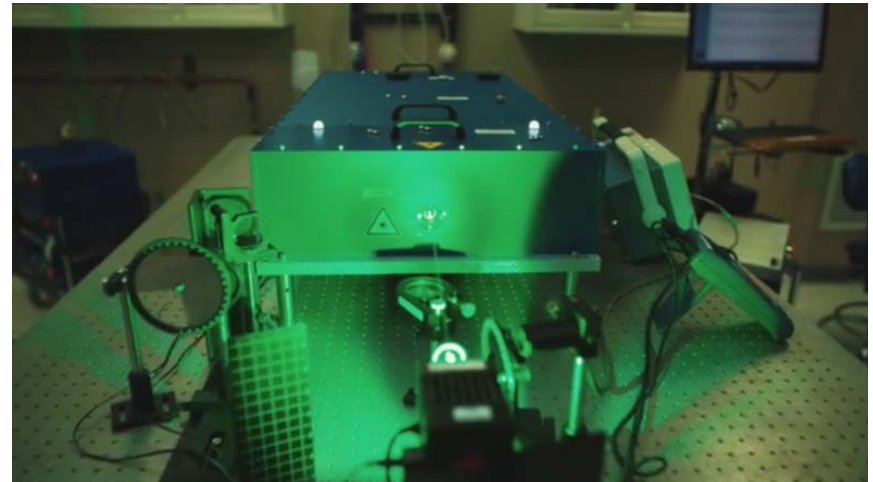


PIV Laser Product Platform

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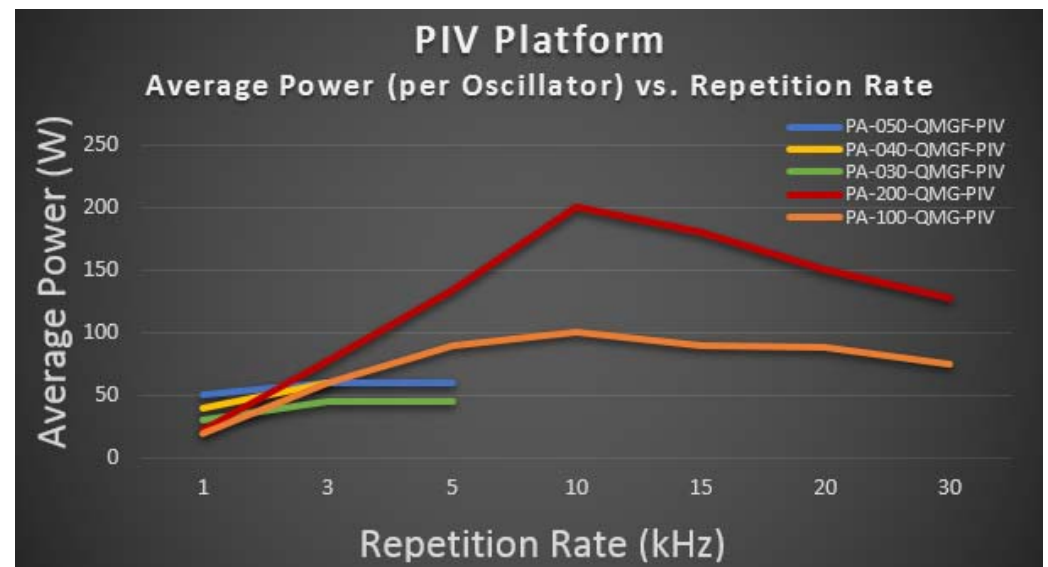
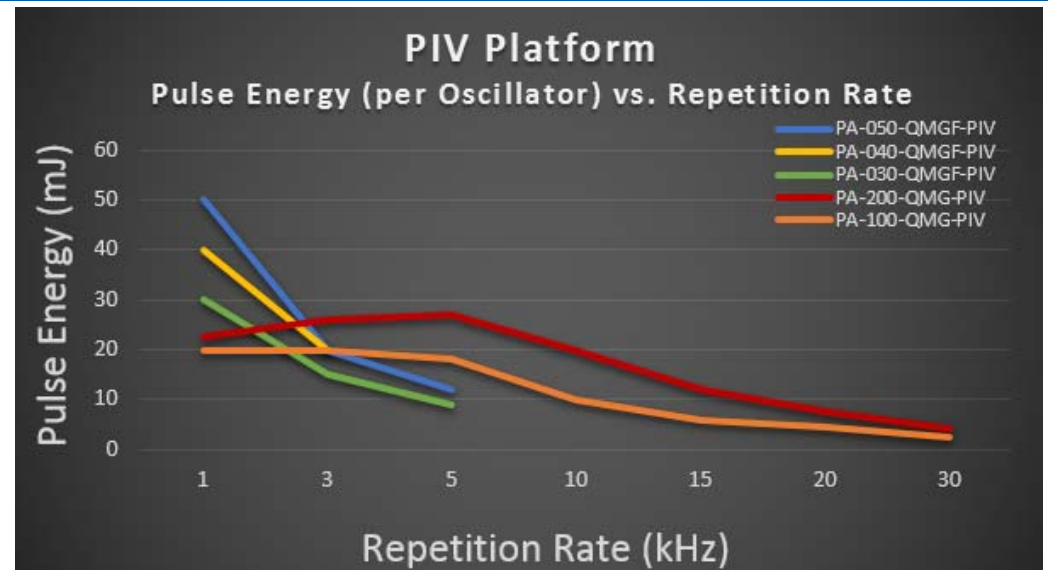


Cutting Edge Optronics

Cutting Edge Optronics PIV Laser Platform



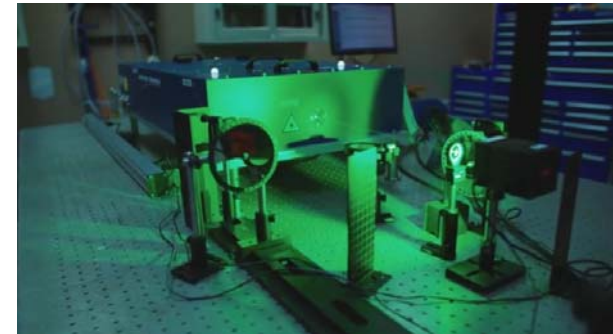
Cutting Edge Optronics manufactures an all diode-pumped scalable family of lasers specifically designed for particle image velocimetry applications. Within the Patara-HP™ laser system platform, CEO offers five laser models that output dual oscillator single coaxial beams ranging from 2mJ – 50mJ energy per pulse (per oscillator) over a repetition rate range of single shot to 30 kHz.



Model	Output / Pump	Rep Rate	Gain Medium
PA-100-QMG-PIV	100 W / CW	10 kHz	Nd:YAG
PA-200-QMG-PIV	200 W / CW	10 kHz	Nd:YAG
PA-030-QMGF-PIV	30 mJ / CW	1 kHz	Nd:YLF
PA-040-QMGF-PIV	40 mJ / CW	1 kHz	Nd:YLF
PA-050-QMGF-PIV	50 mJ / QCW	1 kHz	Nd:YLF

PIV Laser Requirements

- Tracking high speed particles requires short exposure time and sufficient illuminating laser light for the camera.
 - Lasers with short pulse width and high pulse energy are preferred.
 - For high speed PIV applications, high frequency lasers are required.
- PIV measurements rely on precise timing of the illumination laser sources.
 - Low jitter of each laser is required.
 - Matching beam quality and divergence angle between the two lasers creates optimal overlap in space.



PA-050-QMGF-PIV: Bench Test Setup



PA-050-QMGF-PIV: Light Sheet Particle Illumination

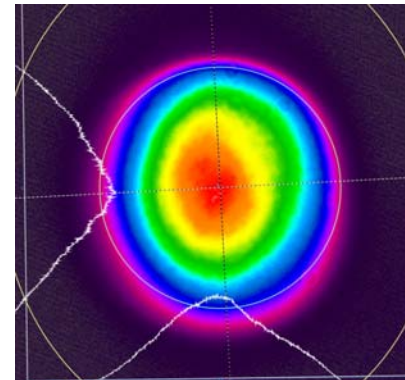
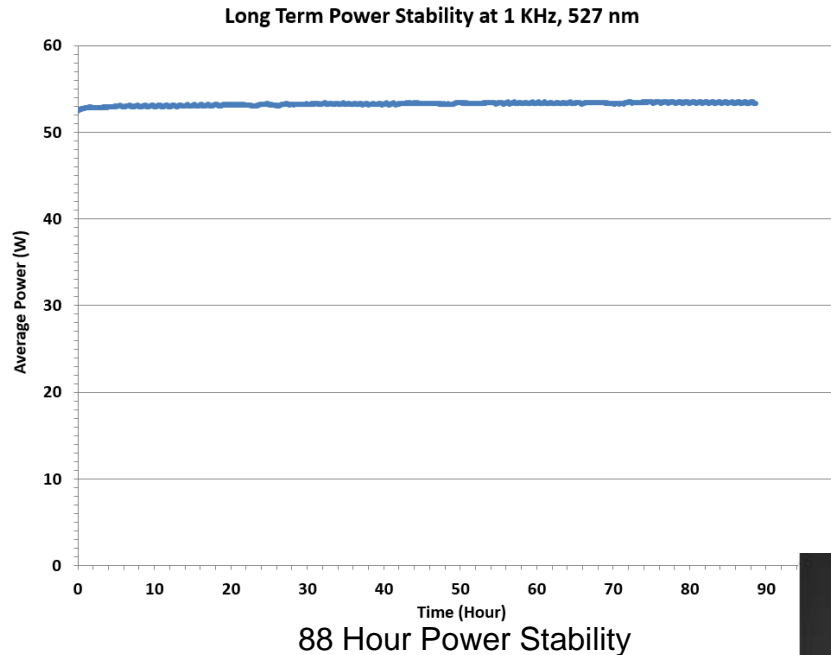


PA-050-QMGF-PIV: Adjustable Pulse Separation

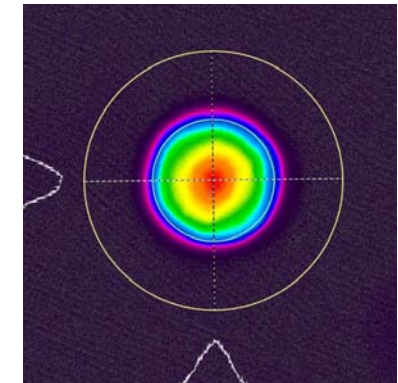
Approved for public release; Northrop Grumman 17-1146 dated 5/23/17.

PA-050-QMGF-PIV Oscillator Performance Data

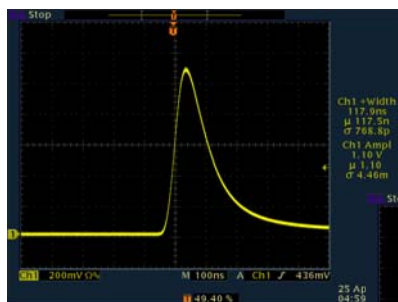
50mJ / 527nm @ 1kHz



Beam Profile @ Output Window

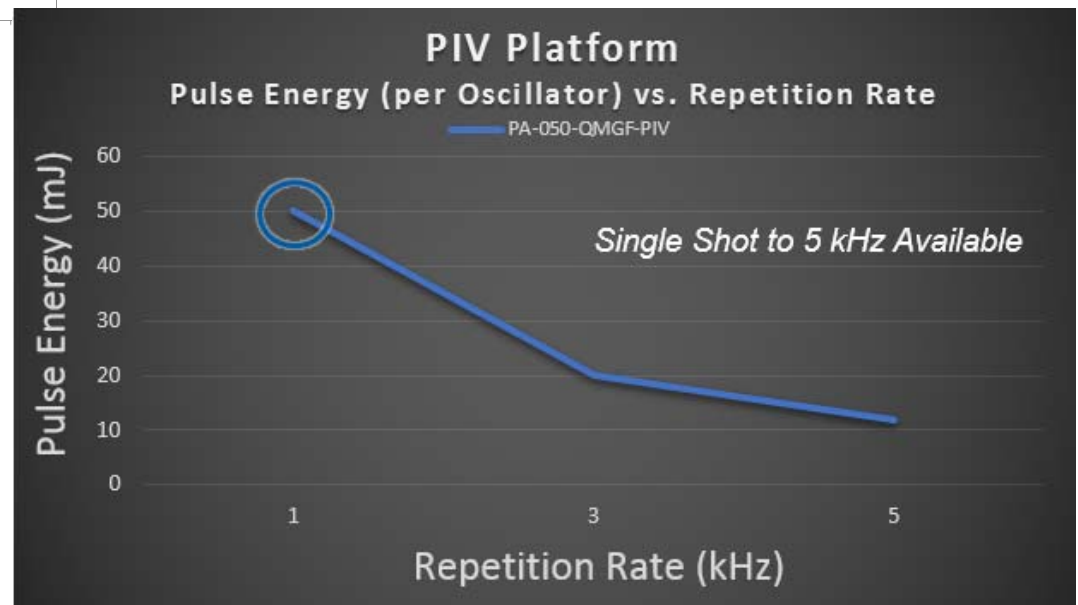
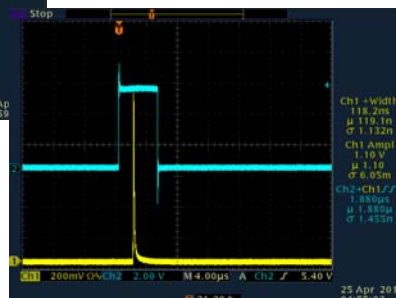


Beam Profile @ Beam Waist (Far Field)



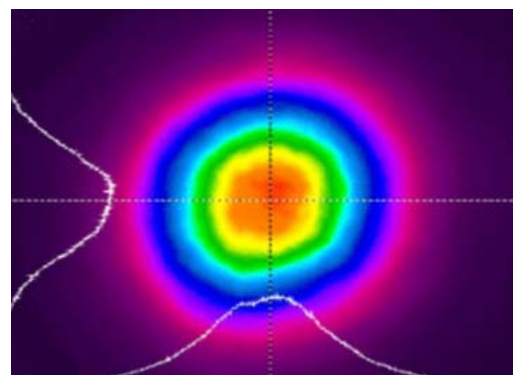
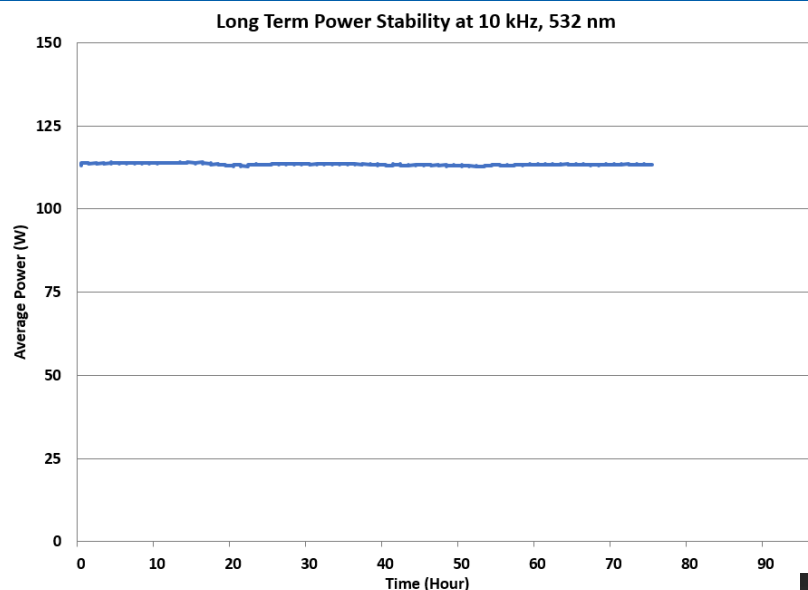
Jitter
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 < 4ns Measured

Pulse Width
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 < 120ns Measured

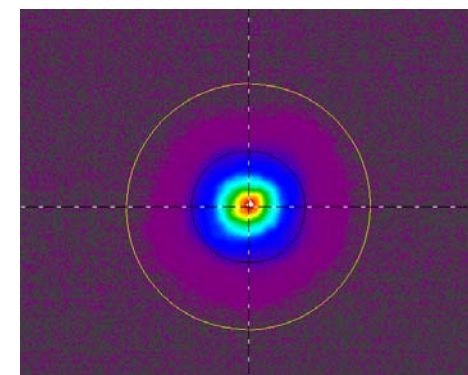


PA-100-QMG-PIV Oscillator Performance Data

100W / 532nm @ 10kHz

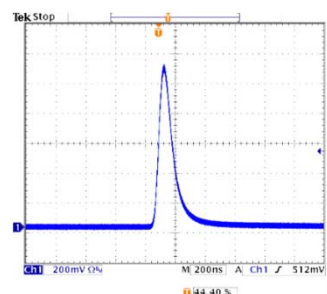


Beam Profile @ Output Window



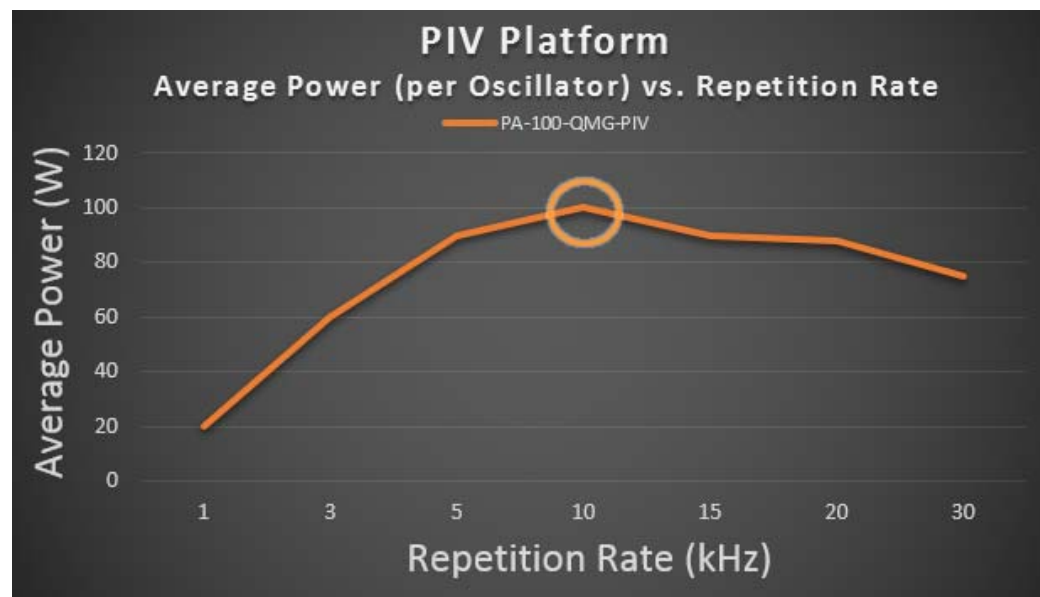
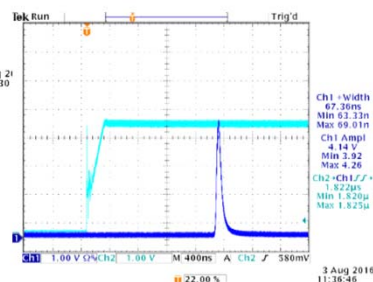
Beam Profile @ Beam Waist (Far Field)

75 Hour Power Stability



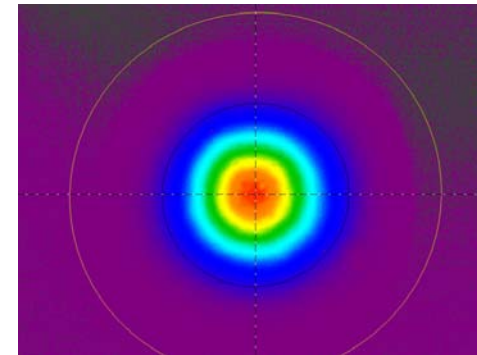
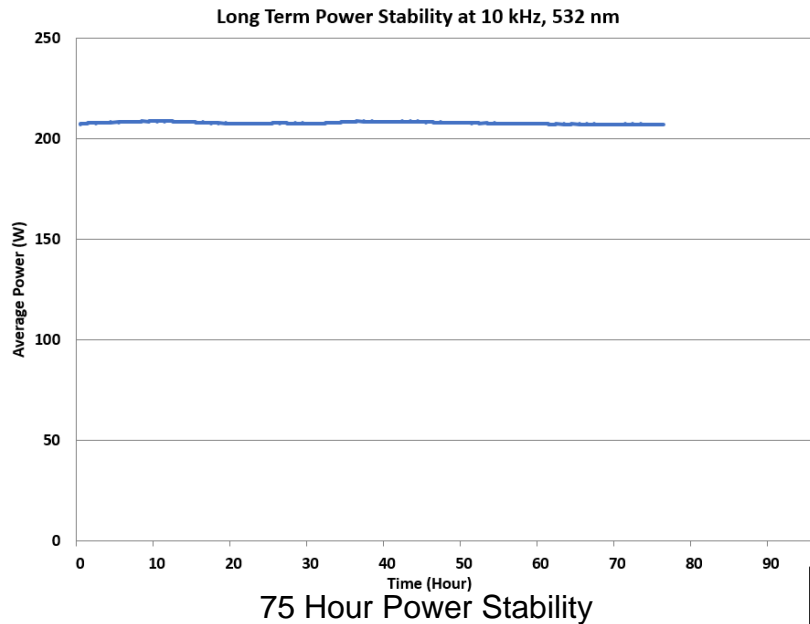
Jitter
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Pulse Width
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 < 100ns Measured

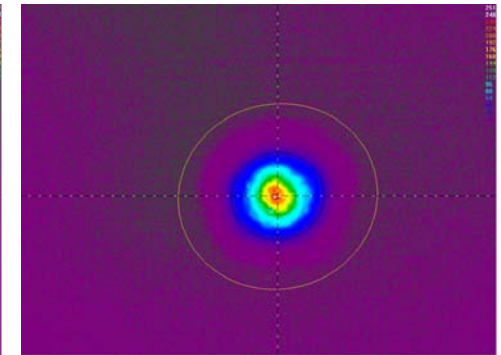


PA-200-QMG-PIV Oscillator Performance Data

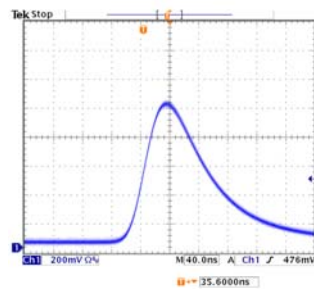
200W / 532nm @ 10kHz



Beam Profile @ Output Window

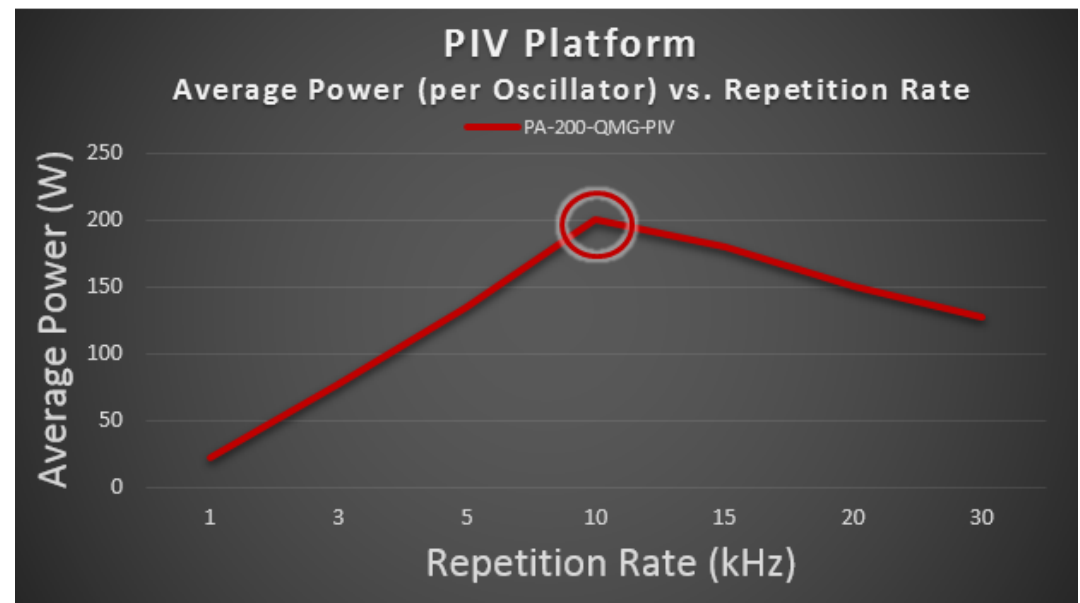
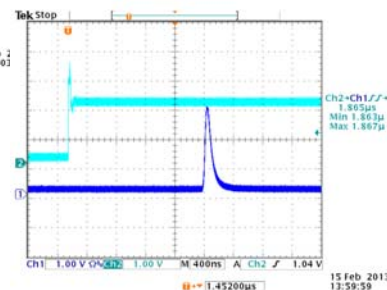


Beam Profile @ Beam Waist (Far Field)



Jitter
 < 10ns Specified
 < 4ns Measured

Pulse Width
 < 120ns Specified
 < 100ns Measured





Patara™ Laser System Reliability

Patara™ Laser System - Reliability

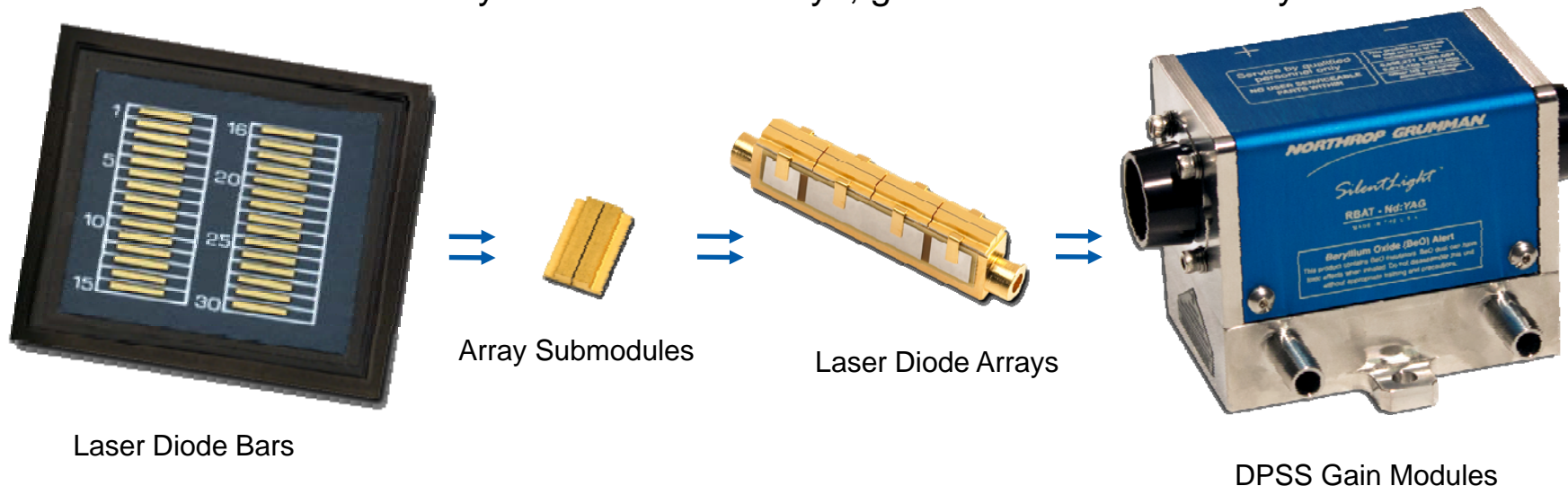


- All Patara™ laser systems feature NGCEO laser diodes and DPSS gain modules
 - Both are DPSS laser industry standards
 - >10,000 modules installed worldwide
 - Laser diode lifetime in the lasers routinely exceeds 15,000 operating hours
 - Confidently expect a diode lifetime of a minimum 10,000 hours
 - Economical laser diode refurbishment at end of life
- Patara™ laser system
 - Strong industrial history with 100's of field-proven lasers operating world-wide
 - Installations at universities, US National Labs and international R&D facilities
 - Components are meticulously cleaned prior to assembly
 - Manufactured in a clean, particle controlled environment
 - >100 hr test on every laser prior to shipment
- eDrive laser system controller
 - Designed and manufactured at CEO
 - Extensive system protection interlocks and on board diagnostics
 - Robust, reliable and easy to use

High Reliability Laser Diodes



- All diode bars for laser gain modules are fabricated at CEO
 - Wafer processing, device fabrication, packaging & testing are all performed in Class 100 - 10,000 clean rooms
 - Every wafer is lot tested for long term degradation
 - At higher than nominal operating current
 - 1000-2000+ hours
 - Every laser diode bar and array is tested prior to installation in a gain module
 - 100% bar traceability from wafer to arrays, gain module and laser system



High Quality DPSS Gain Modules



- The DPSS gain module is *the* critical component in a DPSS laser
 - Key contributor to all of the important DPSS laser parameters
 - Mode quality
 - Beam roundness
 - Beam pointing
 - Pulse to pulse stability
 - Average power output



Cutting Edge Optonics has manufactured >15,000 Gain Modules

Patara™ Laser System Background



Patara – Introduced 2006

Power	Wavelength	Rep Rate Range
16W-20W	1064nm / 532nm	4 – 10 kHz

Notes: Turn key TEM₀₀ DPSS laser system with superior beam pointing, pulse-to-pulse stability and high conversion efficiency. With 100's of world-wide installations, the system became a workhorse for micromachining, diamond processing and medical applications.

Patara-HP – Introduced 2010

Power	Wavelength	Rep Rate Range
50W-400W	1064nm / 532nm	1 – 30 kHz

Notes: Developed, as a higher power version, with similar architecture to service more industrial and scientific applications. The flexibility of this system has allowed its utilization in a wide range of applications from paint stripping to Ti:Sapphire pumping.

IKLWA – Introduced 2012

Power	Wavelength	Rep Rate Range
16W-20W	1064nm / 532nm	4 – 10 kHz

Notes: Developed as a more economical solution with virtually the same form, fit and function as the Patara™ laser system. Innovative manufacturing techniques were developed to drive costs down while preserving critical functions to serve the micromachining and diamond processing markets.

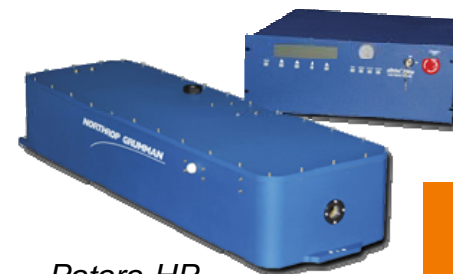
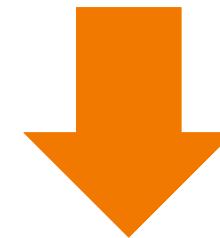
Patara-PIV – Introduced 2016

Power (per oscillator)	Wavelength	Rep Rate Range
30W-200W	532nm / 527nm	Single Shot – 30 kHz

Notes: Developed specifically for the scientific field of particle image velocimetry with a decade of knowledge in manufacturing industrial and scientific lasers. The combination of technology and innovative manufacturing techniques makes this an affordable yet progressive product line.



Patara



Patara-HP



IKLWA



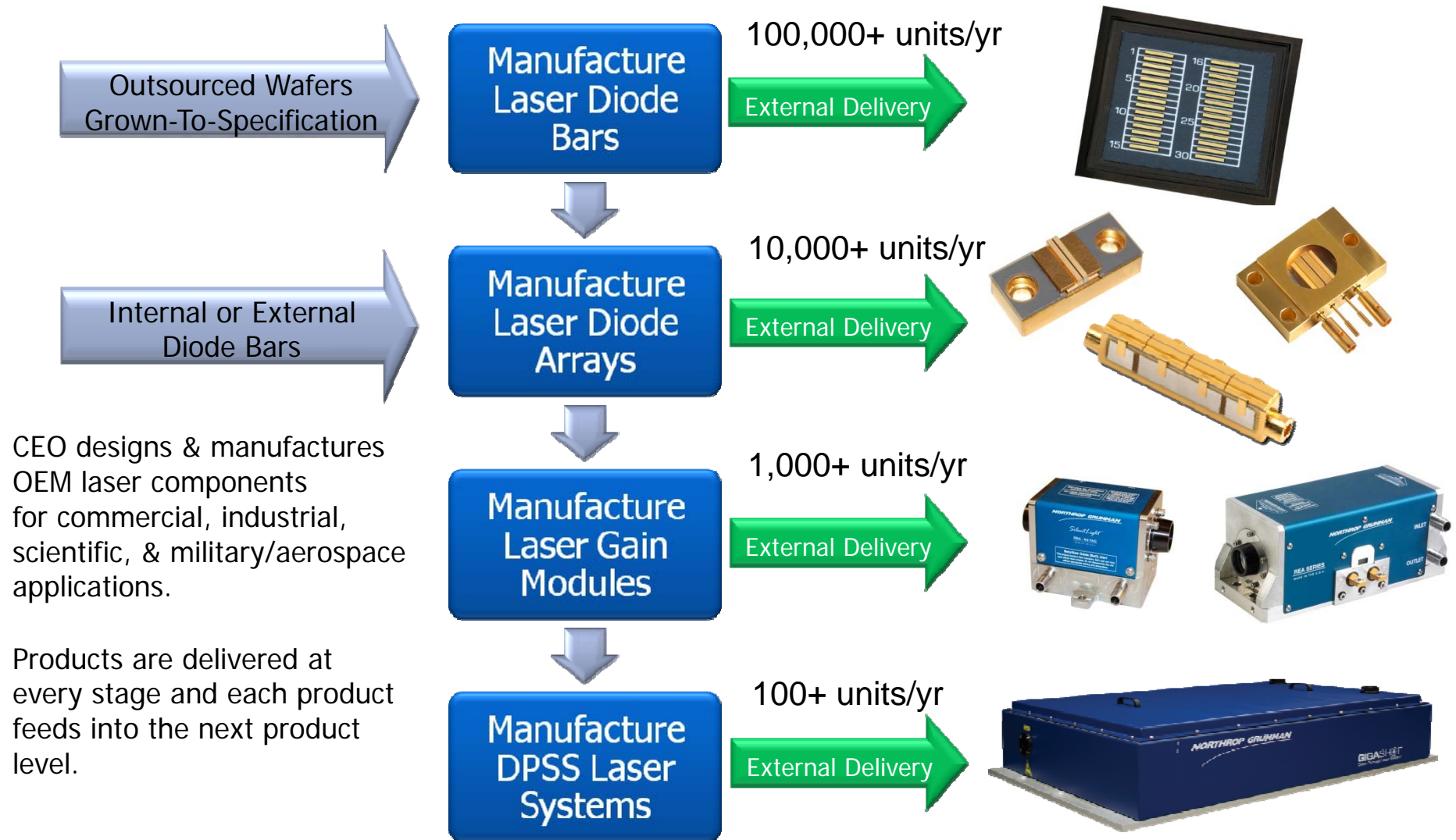
Patara-PIV



Why Cutting Edge Optronics?

25 Years DPSS Laser Manufacturing Experience


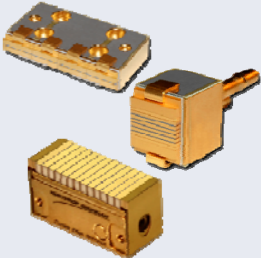


CEO Manufactures Every DPSS Laser Component



25 Years DPSS Laser Manufacturing Experience

CEO is Experienced in a Variety of Markets



Product		Annual Volume	Typical Markets
	Raw Diode Bars	100,000+	Hair Removal, Material Processing Systems, Medical Systems, etc.
	Diode Arrays	10,000+	Direct Energy Weapons, LIDAR, Diamond Processing Machines, Hair Removal, Material Processing Machines, Scientific Lasers, etc.
	Gain Modules	1,000+	Diamond Processing, Marking Machines, Material Processing, High Energy Laser Systems, Scientific Lasers, etc.
	Laser Systems & Electronics	100+	LIDAR, Diamond Processing, Material Processing, Laser Peening, Spectroscopy, Laser Cleaning, LCD Repair, Remote Sensing, PIV, Ranging, Ultrafast Pumping, etc.

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

