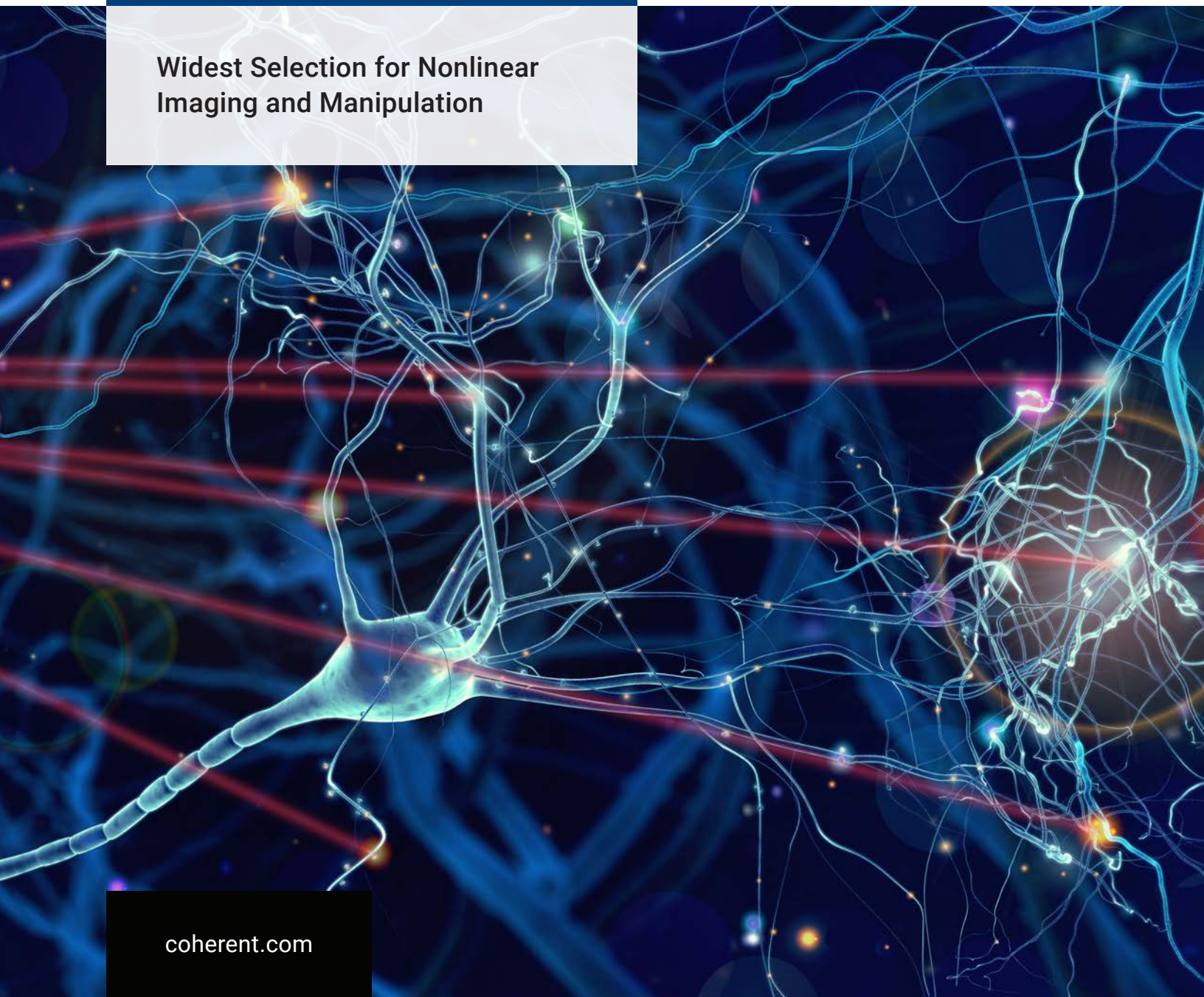
COHERENT

Lasers for Multiphoton Microscopy

Widest Selection for Nonlinear Imaging and Manipulation



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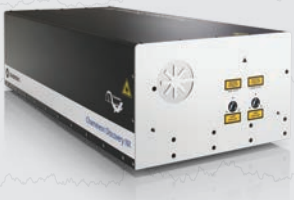
COHERENT

Your Partner in Multiphoton Excitation Microscopy

Over the past decade, the capability and variety of non-linear imaging techniques flourished almost beyond imagination. The variety of applications, together with the expanding number of probes, beam manipulation, delivery and excitation schemes is a strong driving force for the continuous advancements in parameters and functionality of the femtosecond laser sources at Coherent. We offer the widest selection of femtosecond laser tools for all aspects of non-linear imaging. Whether you are interested in label-free techniques, structural or functional brain imaging or three-photon imaging, our combination of performance, reliability and application and service support ensures your experimental success.



Compact Fixed Wavelength Sources

• Dedicated imaging tasks
• OEM friendly
• Clinical directions

Axon
• Compact and low cost
• 780, 920 or 1064 nm
• <150 fs with GDD precompensation
• Built in fast power modulation (Total Power Control)

Tunable Imaging Lasers

• Mainstream imaging needs
• Suitable for core facilities
• Automated turnkey operation

Chameleon Discovery NX
• 660 to 1320 nm
• 3.6 W at 800 nm
• >3.5 W at 1040 nm second beam
• Built in fast power modulation (Total Power Control)

Chameleon Ultra II
• 680 to 1080 nm
• >3.5 W at 800 nm

Chameleon Vision II
• Adds Dispersion Precompensation
• 680 to 1080 nm

Chameleon Vision S
• Short Pulses (75 fs)

Lasers for Advanced Imaging

• Performance oriented for deeper, faster or wider imaging
• 3P imaging and Optogenetics
• Less turnkey, but highly flexible

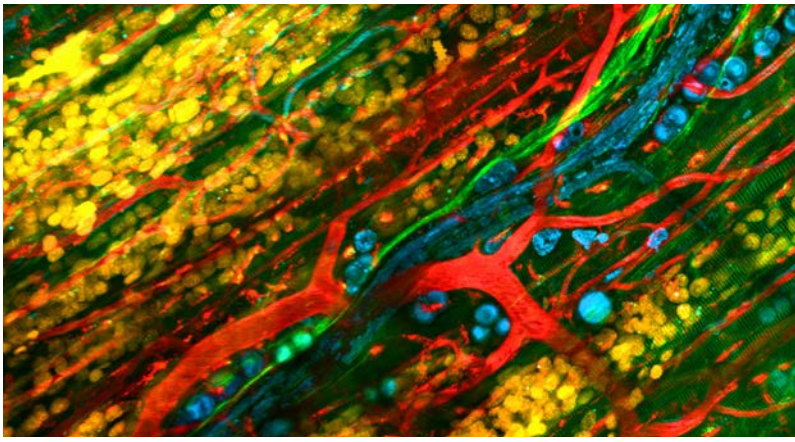
Monaco
• High power fiber laser
• 1035 nm
• <350 fs
• Up to 80 µJ
• Single-shot to 50 MHz

OPerA F
• High energy tunable OPA
• Pumped with Monaco
• 650 to 2500 nm
• up to 4 MHz
• <100 fs (with optional compressor)

The Chameleon has proved itself to be an ideal laser source for our multiphoton microscopes, delivering a wealth of publishable data. We are excited to now get the latest Discovery lasers with dual wavelength output.

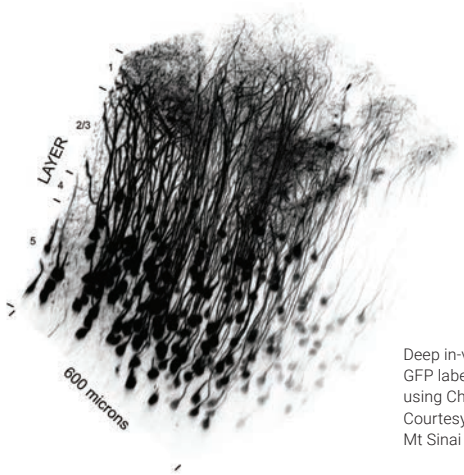
—Dr. Pedro Garcia da Silva, Champalimaud Center for the Unknown, Lisbon

Courtesy of A. Packer, University of Oxford.



Chameleon Ultra II and Compact OPO used with multiple probes and modalities to image tumor invasion. Courtesy of B. Weigelin and P. Friedl, Radboud University Nijmegen

Courtesy of N. Merovitch, The Hospital for Sick Children, University of Toronto.



Deep in-vivo imaging of GFP labelled H-line mouse using Chameleon Vision II. Courtesy of G. Ellis-Davies, Mt Sinai School of Medicine.

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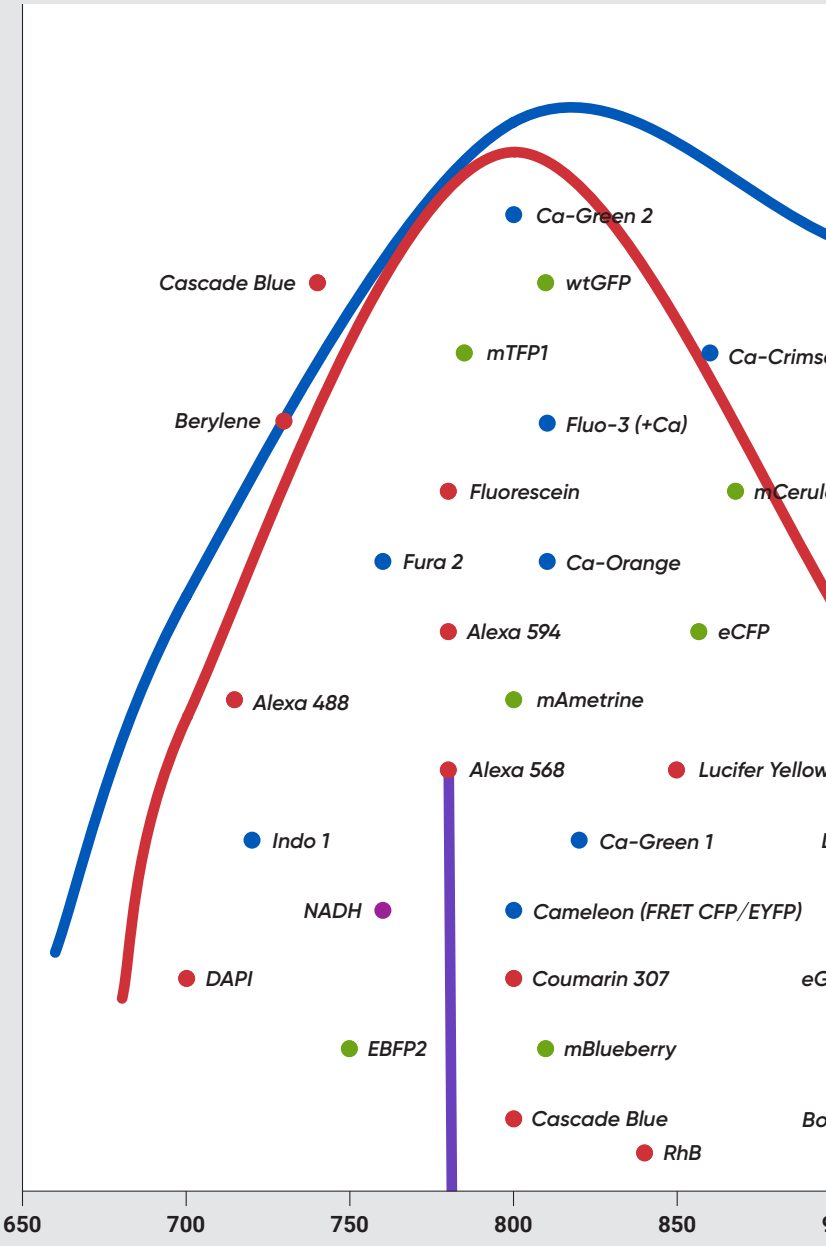
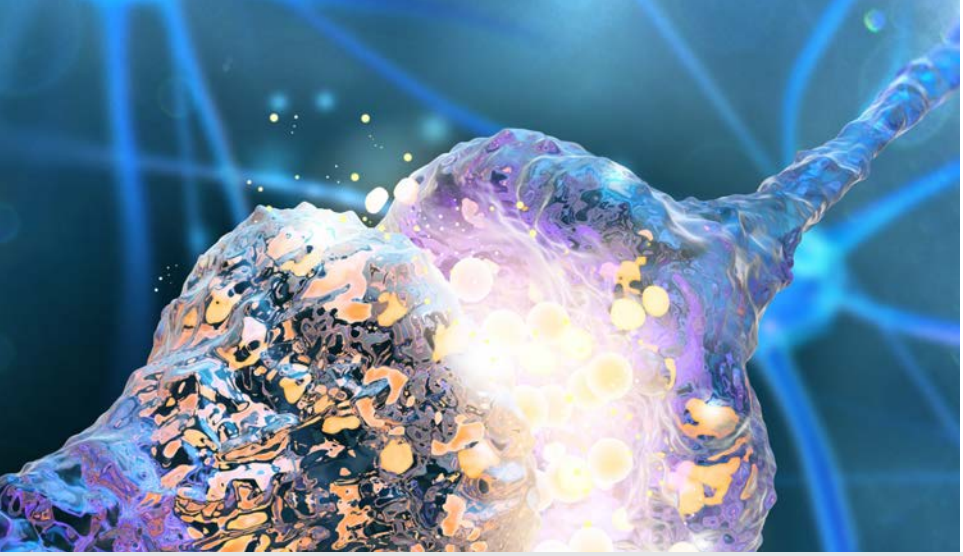
Tunable and Targeted Sources
for All Probes

Coherent offers the widest selection of lasers for nonlinear imaging to meet your microscopy needs. All models are fully automated, turn-key solutions.

The tunable wavelength ranges of Chameleon Discovery NX and our Ti:Sapphire lasers covers the absorption lines of all popular dyes, fluorescent proteins, opsins, or calcium indicators, and can be used for label-free imaging.

Fixed-wavelength Axon lasers are also shown in the graph and the available wavelengths neatly cover the main red, green, and blue probes.





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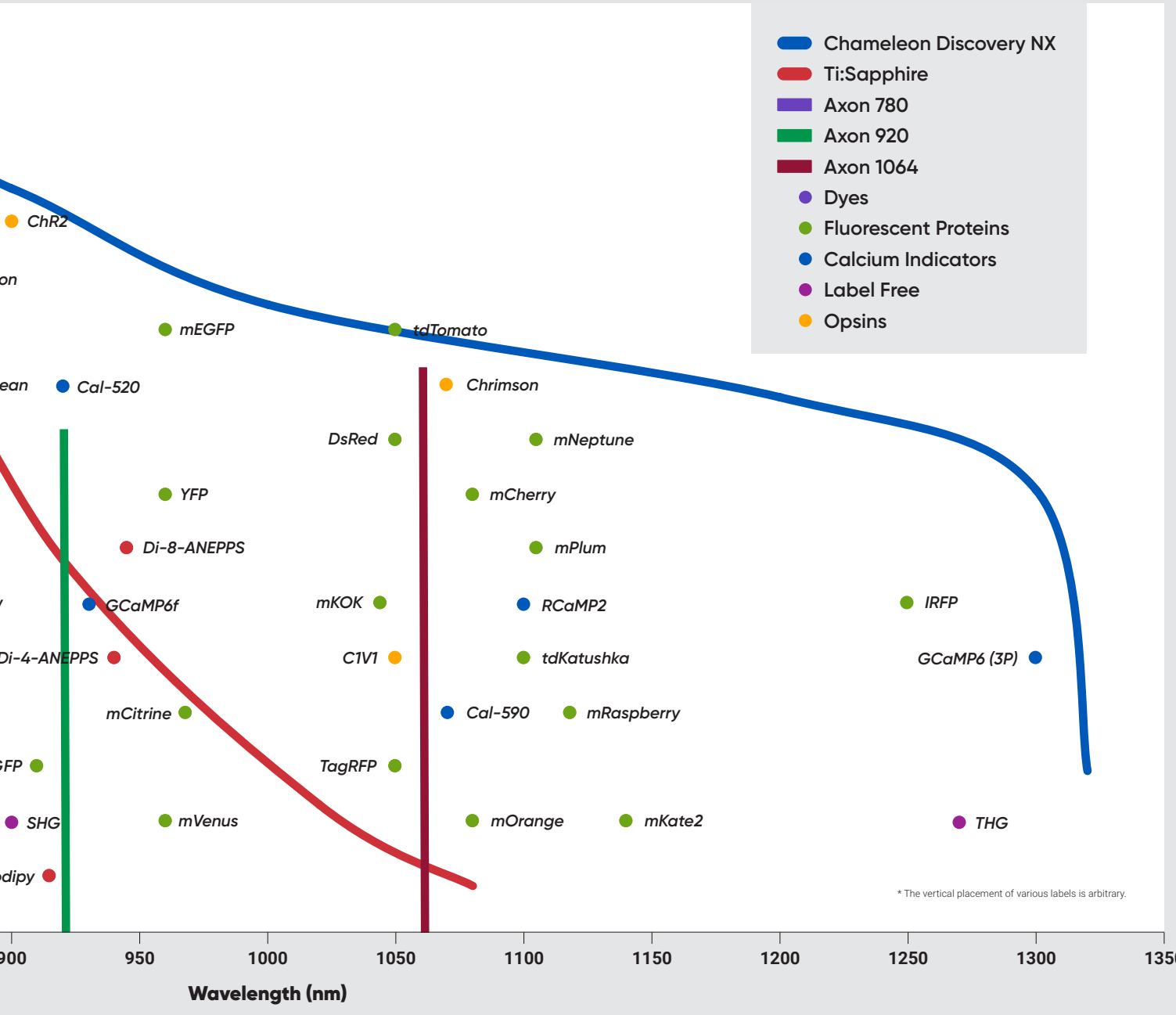
Chameleon Discovery NX
Ti:Sapphire
Axon 780
Axon 920
Axon 1064
Dyes
Fluorescent Proteins
Calcium Indicators
Label Free
Opsins
ChR2
mEGFP
tdTomato
Cal-520
Chrimson
DsRed
mNeptune
YFP
mCherry
Di-8-ANEPPS
mPlum
GCaMP6f
mKOK
RCaMP2
IRFP
C1V1
tdKatushka
GCaMP6 (3P)
mCitrine
Cal-590
mRaspberry
TagRFP
SHG
mVenus
mOrange
mKate2
THG
* The vertical placement of various labels is arbitrary.
900
950
1000
1050
1100
1150
1200
1250
1300
1350
Wavelength (nm)

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Chameleon Discovery NX

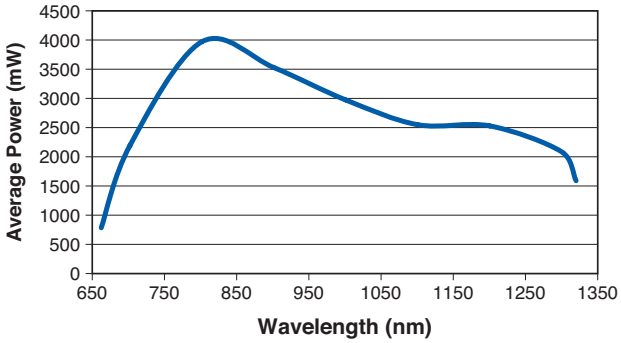
Dual Output, Broadly Tunable Laser
with Dispersion Precompensation

Chameleon Discovery NX is a next-generation automated, ultrafast tunable laser with enhanced performance to address the most demanding requirements in two-photon imaging and spectroscopy.

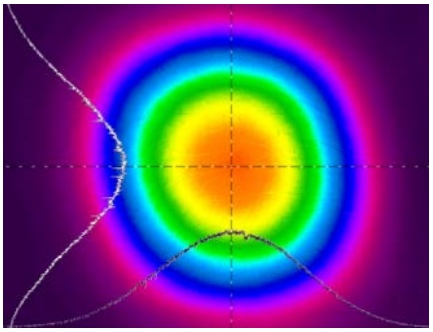
Chameleon Discovery NX delivers the highest power to enable deep in-vivo excitation of all popular fluorescent probes, whilst the expanded dispersion precompensation range ensures the shortest pulses at the sample plane for a variety of microscopy configurations.

High peak power with dispersion precompensation ensures optimized performance for label-free techniques such as SHG and THG. A high-power, 1040 nm secondary output further allows simultaneous, multiwavelength excitation of multiple fluorescent markers or photoactivation of optogenetics probes.

Chameleon Discovery NX:
Typical Tuning and Power

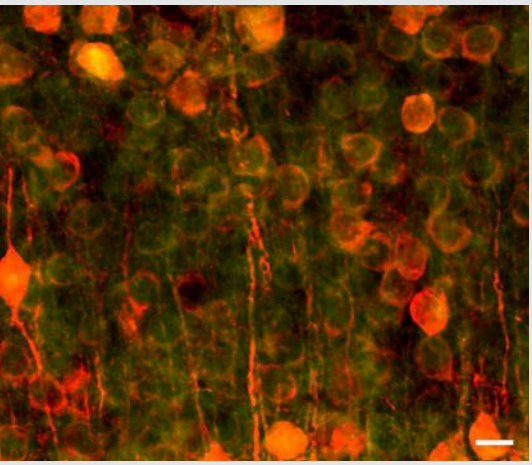


Chameleon Discovery NX:
Beam Profile at 900 nm

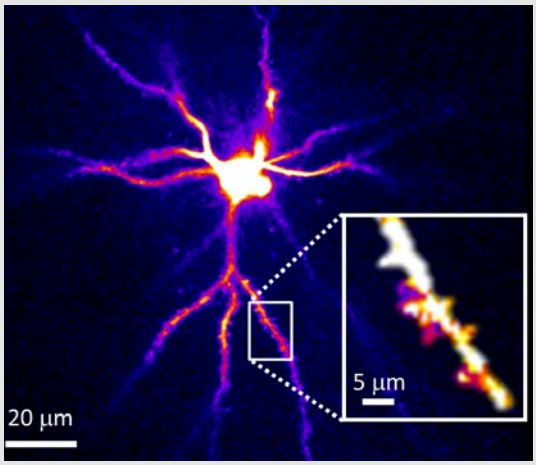


Chameleon Discovery NX	Optical Output A	Optical Output B
Wavelength Range (nm)	660 to 1320	1040 (fixed)
Max. Average Output Power (mW)	3600 at 800 nm	>3500
Pulse Duration[1,2] (fs)	100	140
Repetition Rate (MHz)	80 ±0.5	80 ±0.5
Beam Mode[1]	M^2 <1.2	M^2 <1.2
Beam Diameter[1] (mm)	1.2 ±0.2	1.2 ±0.2
Astigmatism[1] (%)	<20	<25
Noise[1,3] (%)	<0.5	<0.25
Power Stability[4] (%)	±1	±1

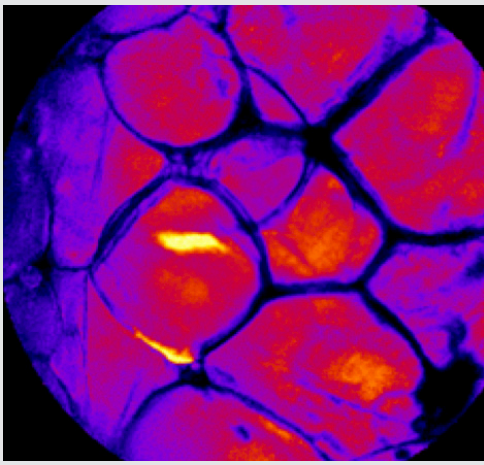
1 At 900 nm.
2 Assumes $sech^2$ pulse shape.
3 RMS, 10 Hz to 10 MHz.
4 Power drift in a 2 hour period after 1 hour warm-up and ±1°C ambient temperature change.



GCaMP6 expression in the mouse cortex with excitation at 920 nm. Courtesy of T. Fellin, IIT Genoa.



Average projection of a z-stack showing the soma of a layer V pyramidal neuron expressing a green fluorescent indicator in an anesthetized mouse. Courtesy of T. Fellin, IIT Genoa.



CARS image showing lipid droplets (2850cm^{-1}) in human colon (ex-vivo). Courtesy of H. Rigneault, Institut Fresnel, Marseille.

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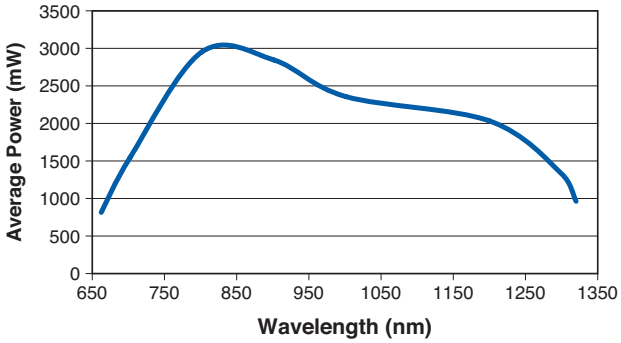
Chameleon Discovery NX TPC

Integrated Laser Modulation for Two-Photon Microscopy

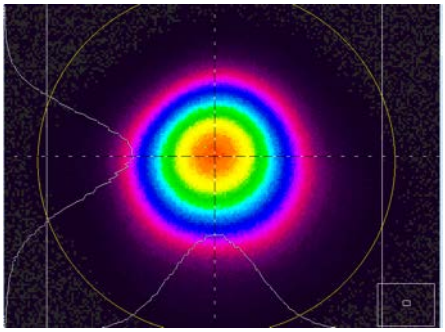
Most modern laser scanning two-photon microscopes require fast modulation speeds. For example, one would need to modulate laser power levels for “flyback operation” blanking in resonant scanning set up, do the power levelling for sinusoidal speed variations or vary power levels for different imaging depths. In the case of using resonant galvometric scanners, the resulting rise/fall times can be as short as a few microseconds. In this domain, one must consider optical modulation methods.

Total Power Control (TPC) option, available with our Chameleon Discovery NX and Axon laser systems, uses built-in acousto-optic modulation for fast and high contrast power control, guaranteeing perfect beam parameters directly into the microscope scan head. Based on integrated Acousto-Optic Modulation, TPC provides hands-free automated laser modulation package which is easy to control and saves valuable table space.

Chameleon Discovery NX TPC: Typical Tuning and Power

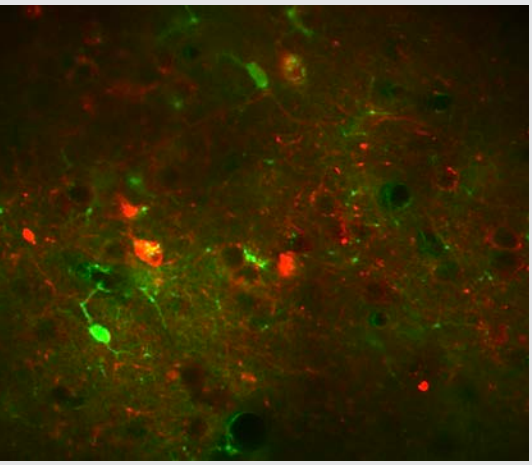


Chameleon Discovery NX TPC: Beam Profile at 1000 nm

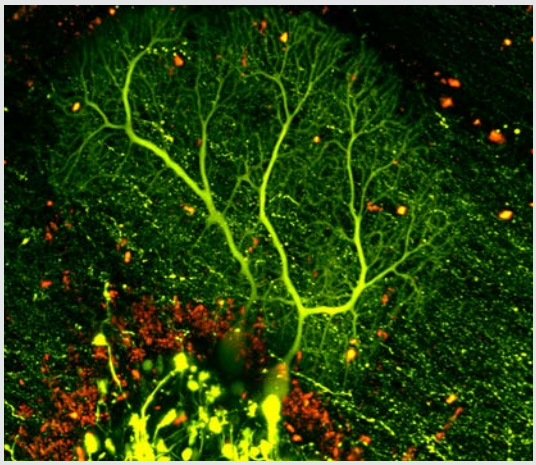


Chameleon Discovery NX with TPC	Optical Output A	Optical Output B
Wavelength Range (nm)	660 to 1320	1040 (fixed)
Max. Average Output Power (mW)	2700 at 800 nm and 900 nm	>2800
Pulse Duration[1,2] (fs)	100	140
Repetition Rate (MHz)	80 ±0.5	80 ±0.5
Beam Mode[1]	M^2 <1.2	M^2 <1.2
Beam Diameter[1] (mm)	1.2 ±0.2	1.2 ±0.2
Astigmatism[1] (%)	<25	<25
Rise/Fall Time (ns)	<400	<400
Contrast Ratio	1000:1	1000:1

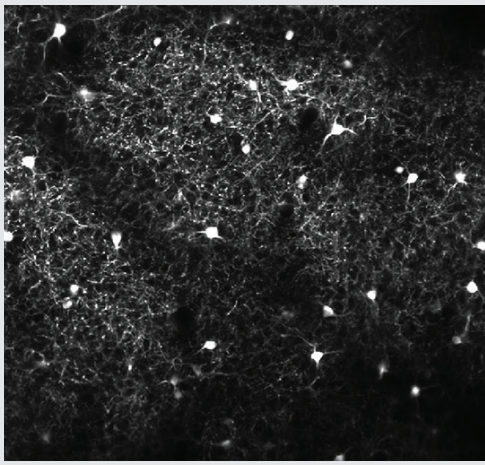
1 At 900 nm.
2 Assumes $sech^2$ pulse shape.



Overlay of in-vivo mouse imaging: Neurons expressing RCaMP1.07 excited at 1100 nm; Astrocytes expressing GCaMP6s excited at 940 nm. Courtesy of Weber Lab, University of Zurich.



Purkinje cells, mouse cerebellum, imaged with Chameleon Discovery TPC. Courtesy of Dr. Y. Savchuk, Marquette University.



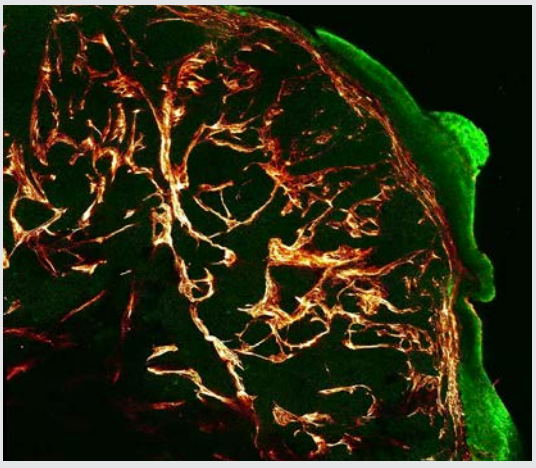
Mouse imaging where GCaMP6s is expressed in somatostatin interneurons. Courtesy of J. Trachtenberg, University of California Los Angeles.

COHERENT

Chameleon Ti:Sapphire Lasers

Tunable, High Power, Hands-free Femtosecond Lasers
for Non-linear Imaging

With thousands of installations worldwide, Chameleon lasers are recognized as the genuine workhorses of the multiphoton imaging community. The highest average power in the Ti:Sapphire laser market enables deep imaging with the fastest scanning technologies. Additionally, Chameleon offers the widest tuning range, ensuring efficient excitation of all popular probes. Wavelengths beyond 1080 nm are accessible with the Chameleon MPX, multiphoton wavelength extension, and other Compact-OPO models



Mouse tumor imaging using SHG method, collagen fibers. Tissue autofluorescence excited at 810nm (green). Courtesy of T. Guilbert, Institut Cochin, Paris.

Chameleon Ultra

The Chameleon Ultra portfolio offers the ideal pulse duration for minimal pulse stretching through most commercial and home built microscope systems. Three models are offered with up to 3.5 W average power and 400 nm tuning range.

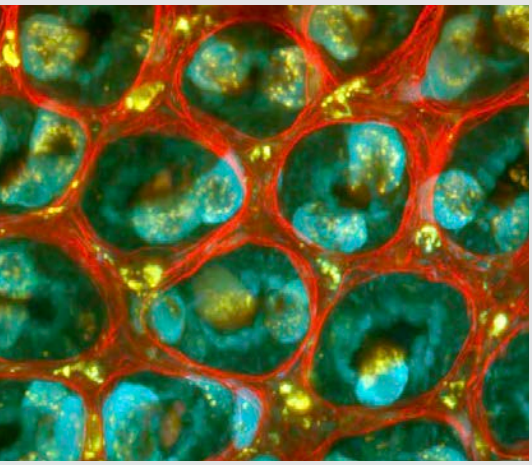
Chameleon Vision

Chameleon Vision adds group velocity dispersion (GVD) precompensation to the Chameleon Ultra platform, ensuring short pulses are delivered right to the sample plane. Multiple dispersion value curves that automatically adjust according to the wavelength of interest can be defined over a wide dynamic range of 0 fs^2 to more than 22,000 fs^2 at 800 nm.

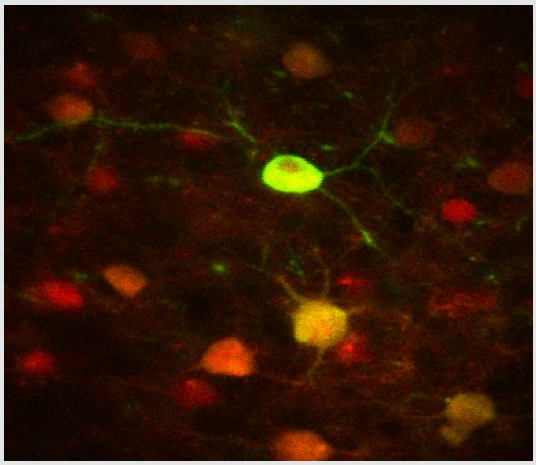
Chameleon Vision S

Where peak power is the key focus of a particular imaging regime, or where linear absorption limits the amount of average power in a sample volume, Chameleon Vision S delivers very short pulses of 75 fs right to the sample plane.

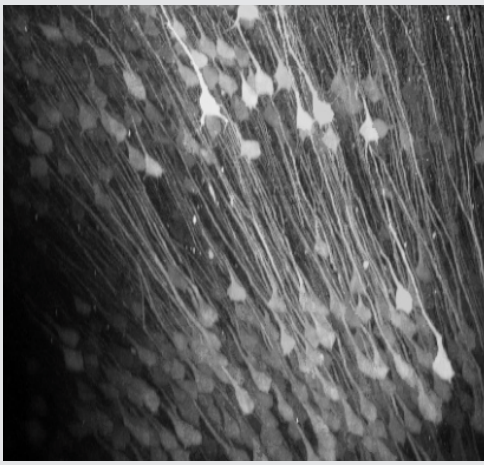
Chameleon	Ultra	Ultra I	Ultra II	Vision I	Vision II	Vision S
Average Power (W, at 800 nm)	>2.5	>2.9	>3.5	>2.5	>3.0	>2.5
Tuning Range (nm)	690 to 1020	690 to 1040	680 to 1080	690 to 1040	680 to 1080	690 to 1050
Pulse Duration (fs, at 800 nm)	140	140	140	140	140	75
Dispersion Precompensation	No	No	No	Yes	Yes	Yes
M^2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Astigmatism (%, at 800 nm)	<10	<10	<10	<10	<10	<10



3D view of murine gastric mucosa. Tissue autofluorescence excited at 710 nm (blue and yellow) Second harmonic generation at 990 nm (red). Courtesy of A. Gebert and T. Fischer, Institute of Anatomy, University Hospital Jena.



In vivo 2-photon image (z-stack, 10 µm) of excitatory neurons in layer 4 of the mouse primary visual cortex. Neurons labelled in red are expressing CaMKII and some of them are additionally labelled with GCamP6f (green). Chameleon Vision S at 920 nm was used for imaging. Courtesy of N. Rochefort, University of Edinburgh.



Reconstruction of GCaMP6 labeled pyramidal neurons in cortical layer 2, 3, and 5 in vivo (Dr. A. Funamizu). Chameleon Vision II at 950 nm. Courtesy of B. Kuhn, Optical Neuroimaging Unit (ONU), Okinawa Institute of Science and Technology.

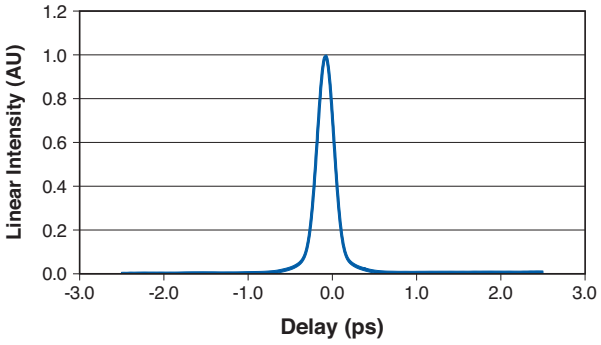
COHERENT

Axon

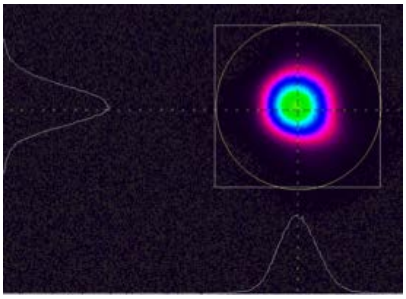
Compact Ultrafast Laser Sources

Axon femtosecond lasers are a family of discrete wavelength, ultrafast sources. Compact design at a breakthrough price point enable a range of life sciences and instrumentation applications. Multiphoton excitation microscopy applications are served by key wavelengths at 780 nm, 920 nm, and 1064 nm, which are perfectly suited for green and red-shifted fluorescent probes, Calcium indicators or label free imaging. Dispersion precompensation is included to optimize short pulses at the sample plane. Built-in modulation is optional for fast power control and flyback blanking. Integrators benefit from a common, plug-and-play interface with the same form factor for each wavelength. Systems are completely air-cooled with no maintenance requirements, enabling a low cost of ownership and long lifetimes.

Typical Autocorrelation: Axon 920

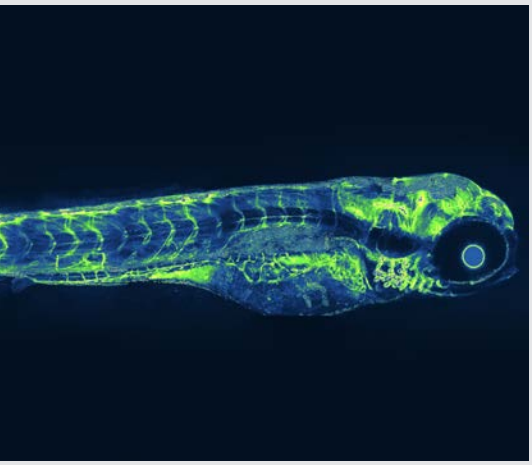


Far Field Beam Profile: Axon

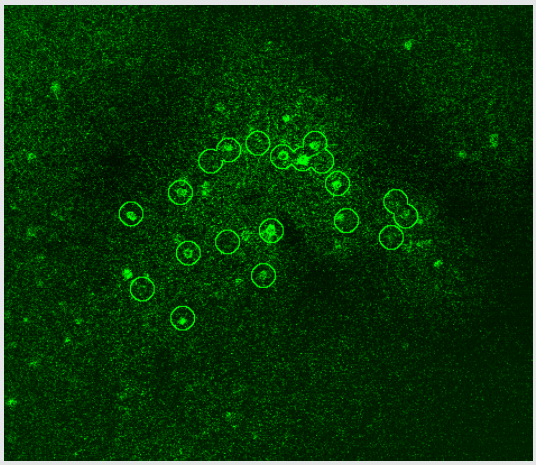


Axon	780-1	780-1 TPC	920-1	920-2	920-1 TPC	920-2 TPC	1064-1	1064-3	1064-1 TPC	1064-3 TPC
Wavelength[1] (nm)	780		920				1064			
Average Power (mW)	800	700	1200	2500	1000	2000	1200	3500	1000	3000
Pulse Duration[2] (fs)	<150									
Repetition Rate (MHz)	80 ±1									
Beam Mode	M^2 <1.3									
Beam Asymmetry[3,4]	0.8 to 1.2									
Beam Diameter[4] (mm)	1.2 ±0.2									

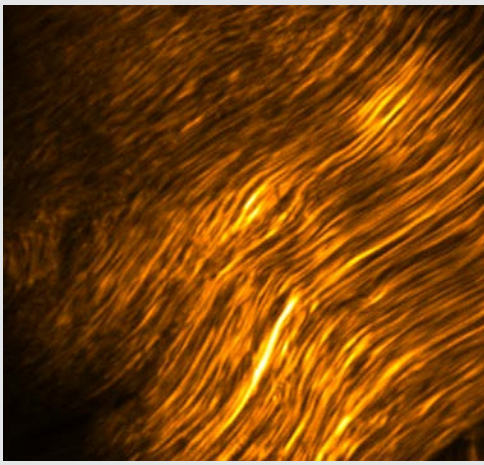
1 Center of mass, ±3 nm.
2 Assumes sech² deconvolution factor.
3 Ratio of waist sizes.
4 Measured at beam waist locations.



Zebrafish embryo, expressing EGFP, Axon 920 nm TPC used for excitation. Courtesy: Júlia Ferrer Ortas, Polytechnique/CNRS/Inserm, Palaiseau, France.



Axon laser used for GCaMP6s Ca++ imaging in mouse following optogenetic stimulation. Courtesy of A. Packer, University of Oxford.



SHG image collected in forward direction of non-labelled collagen fibers from bovine achilles tendon. Courtesy of Dr. P. Loza-Alvarez group, ICFO, Barcelona.

COHERENT

Monaco & Opera

Diode-Pumped Femtosecond High-Energy Laser with Tunable Optical Parametric Amplifier

Engineered for industry but equally at home in the laboratory, Monaco addresses important and novel applications in optogenetics and functional deep imaging for neuroscience. And it does it with unparalleled reliability.

Novel imaging techniques like 3-photon imaging and photo-stimulation with spatial light modulators require unconventional pulse formats. Rather than the common 80 MHz repetition rate used for 2-photon microscopy, the fiber-based Monaco produces pulses at arbitrary repetition rates from single shot to 50 MHz. Tens of watts of output power can be used to stimulate red-shifted opsins at user-selected repetition rates and millisecond bursts of pulses. When operated at 1 to 4 MHz, Monaco produces pulses with energies of tens of microjoules, ideal to pump the tunable parametric amplifier Opera-F.

The tunable output of Opera-F matches key wavelengths used for advanced functional imaging, like 920 nm for 2-photon stimulation of Opsins, and 1300 and 1700 nm for deep 3-photon imaging.

High-Energy/High Repetition Rate

Monaco's energy per pulse—hundreds of times higher than other lasers—enable fast activation/imaging of neuron populations expressing red-shifted optogenetic probes like C1V1 and Calcium indicators of the RCaMP family.

Monaco	1035-80-60	1035-40-40
Center Wavelength (nm)	1035	1035
Average Power (W)	60	40
Energy/Pulse (mJ)	80 (at 750 kHz)	40 (at 1 MHz)
Pulse Duration (fs)	<350	<350
Repetition Rate	Single-shot to 50 MHz	Single-shot to 50 MHz

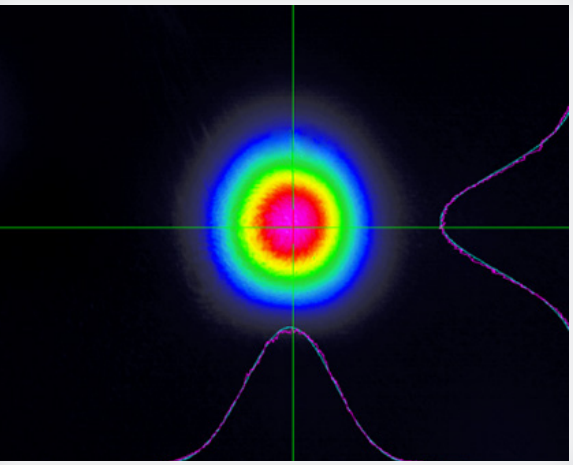
HALT Designed/HASS Verified

Monaco's reliability is assured through the HALT (Highly Accelerated Life Test) and HASS (Highly Accelerated Stress Screen) protocols employed during development and throughout production. Coherent pioneered HALT/HASS, bringing unrivaled standards of reliability and quality to femtosecond applications.

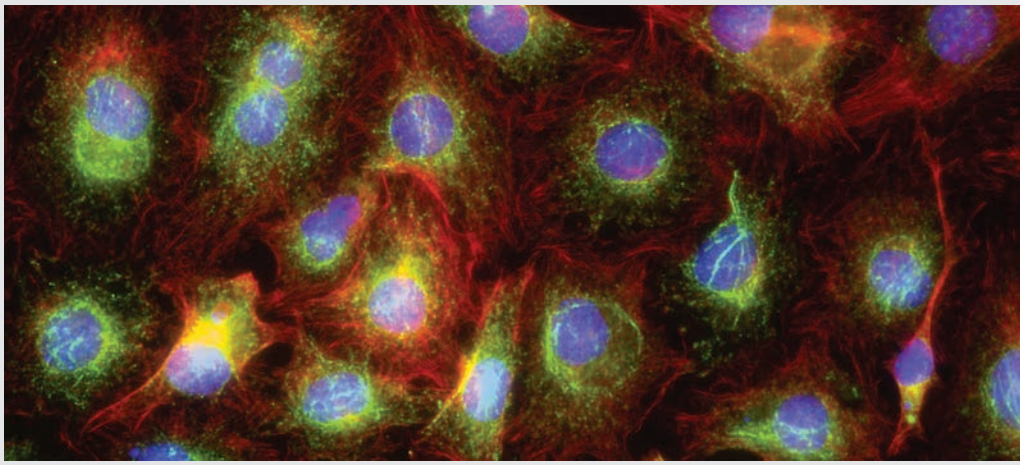
Opera Optical Parametric Amplifiers

Opera-F and Opera-HP provide unique average power and tuning capabilities from the UV to the Mid-IR up to 4 MHz repetition rate. The wavelength region of interest for biological imaging can be addressed with pulse durations and tuning ranges optimized for the specific application.

Opera	F	HP
Wavelength Range (nm)	650 to 900, 1200 to 2500	630 to 1025, 1045 to 2600
Conversion Efficiency (%)	>10	>10
Pulse Duration (fs)	<100 (with optional compressor)	~150 to 300
Pump Power (W)	up to 60	up to 60
Max Repetition Rate (MHz)	4	2



Monaco Far-Field Beam Profile.

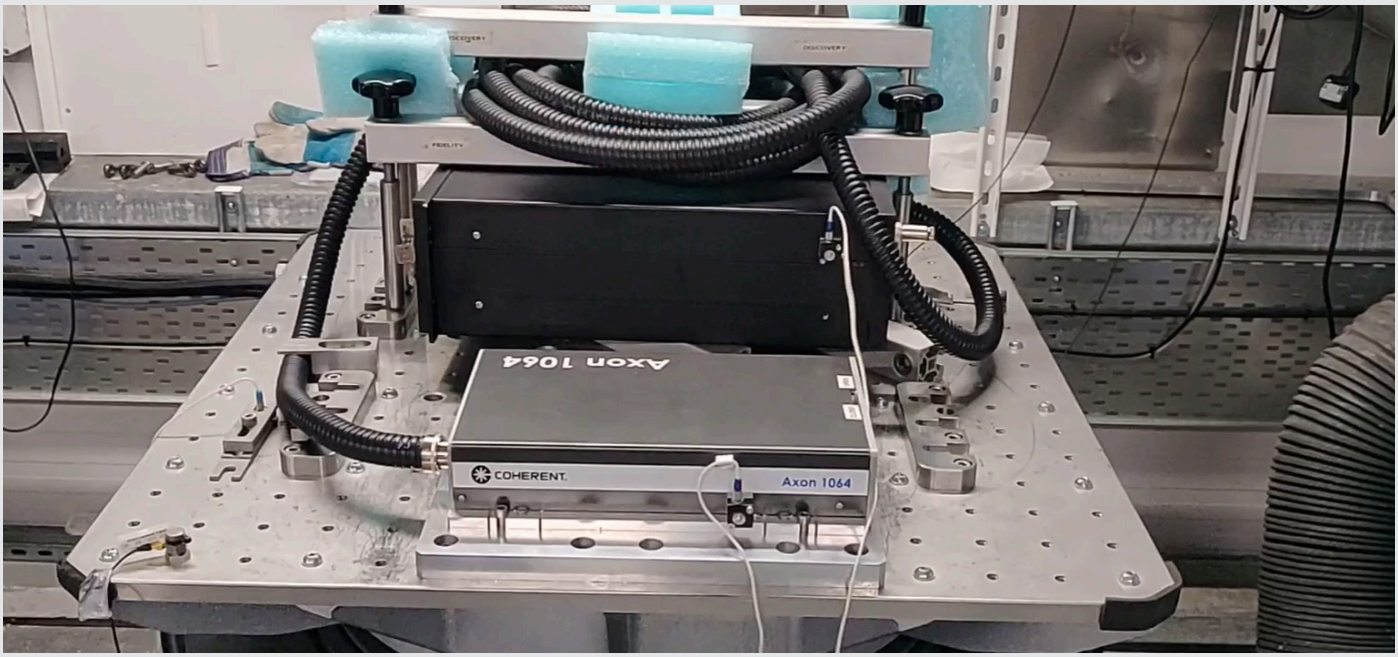


Immortal Cells line 40X.

COHERENT

The Industrial Revolution in Ultrafast Science

More Uptime. More Results.



Axon laser undergoing programmed vibration HASS testing

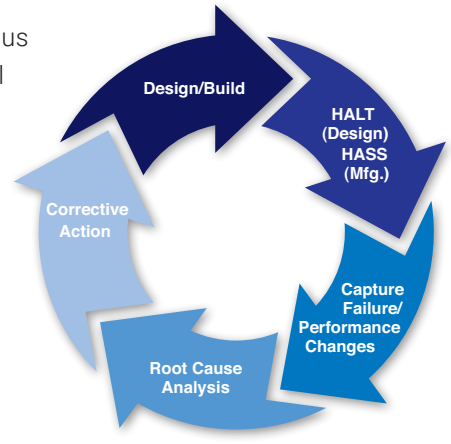
To ensure the maximum uptime to our customers, Coherent uses a rigorous HALT/HASS testing, vertical integration, and the learnings of the industrial lasers markets to design and build ultrafast lasers without compromise.

HALT: Highly Accelerated Life Testing

- Used extensively during the product design phase
- Pushes systems to extreme environmental conditions
- Purposely accelerates and triggers failure mechanisms
- Identifies hidden design weaknesses

HASS: Highly Accelerated Stress Testing

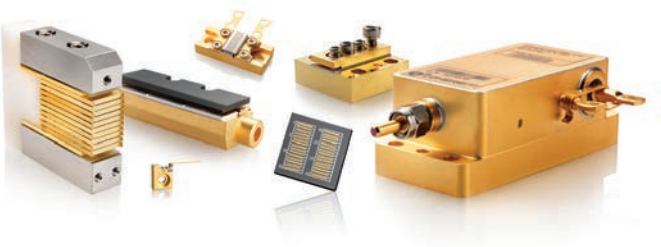
- Used in production testing
- Stresses to parameters defined by HALT testing
- Screens materials for anomalies or manufacturing defects before lasers are shipped



Industrial Design and Testing

Vertical Integration
Complete Control of Quality

- Coherent is the most vertically integrated company in the laser industry
- Both active and passive mission-critical components are designed and manufactured by Coherent. These include dispersion controlled-mirrors, active and non-linear crystals, laser diodes and optically pumped semiconductors
- In-house supply chain results in more uniform quality and performance, high reliability proven in the overall laser design and undisrupted supply chain
- Better components make better lasers



Industrial Laser Know-How
Decades of Experience

- As one of the world's largest manufacturer's of industrial laser systems, Coherent has developed extensive engineering and manufacturing processes focused on repeatability and reliability
- Coherent scientific lasers benefit from all of these engineering practices bringing performance and reliability to cutting-edge research systems

COHERENT

The Coherent **Service Advantage**

Sustainable Performance

All Chameleon laser users benefit from a three-level rapid response program which maximizes system uptime and ensures minimum disruption to experimental work:

- Remote Service gives customers immediate access to an engineer for rapid system diagnosis. Your laser can be diagnosed and optimized to full specification without additional interruption to your work.
- Our Field Service team is trained to resolve remedial service issues the first time.
- The Coherent Advance Replacement Unit program puts factory certified, "equivalent to new" lasers in your laboratory in advance of your system going hard down. This ensures lowest system downtime for your crucial imaging needs. All parameters, including beam profile, pulse duration and dispersion are fully characterized in a Class 10,000 clean-room to ensure repeatable performance.

What is an Advance Replacement Unit (ARU) and How Does it Help Me?

Opening the laser cavity in the field contaminates the laser and ultimately shortens its life. For that reason, when your Chameleon laser is not performing to specification and the problem cannot be resolved remotely or on-site, you will receive an advance replacement laser from our closest inventory. You keep the original laser while waiting for the replacement unit, and we handle all the coordination and costs to ensure a swift and hassle-free recovery. ARU is offered with standard 12-month warranty and with a Gold level service package.

Your ARU laser:

- will be identical to new in terms of performance, specifications, and lifetime
- will be shipped and installed in advance of the original laser being returned
- will be your property (no further changeover required)
- will carry the remainder of the warranty or contract term

Our ARU Promise

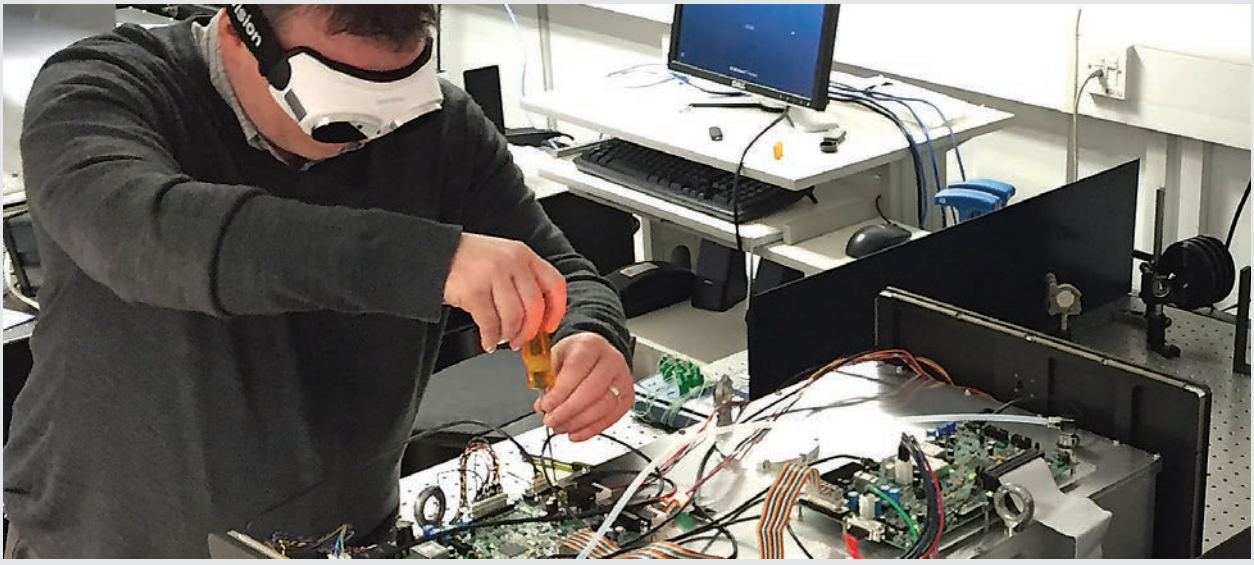
When a replacement unit is required, we commit to shipping it within 5 business days from the day it was ordered. In the event we do not fulfill this commitment, we will extend your existing service contract or warranty by 90 days.

Extended Warranty
Contract Offerings

Tailored to Suit Your Research Priorities

	Bronze Prioritized factory depot repair	**Silver** Replacement ships within 15 days	**Gold** Advanced Replacement Unit (ARU) ships within 5 days
Remote Diagnostics	✔	✔	✔
Field Service	✔	✔	✔
Full Coverage of All Repair Costs	✔	✔	✔
Advanced Replacement Unit (ARU) Program	⊖ Upgrade Optional	⊖ Upgrade Optional	✔
5-Day Shipment Guarantee	⊖	⊖	✔

To ensure maximum flexibility to our customers, the Pay-As-You-Go options are also available for all our service approaches.

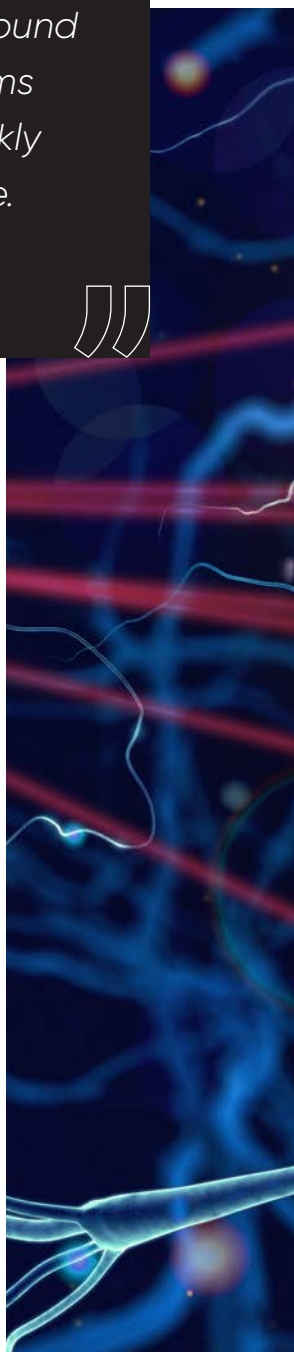


Professional, responsive and effective field service from factory certified engineers.

Your Partner in Multiphoton Excitation Microscopy

Our research often depends on specialized and expensive lasers that are difficult to replace. So what's important to us is to have a company that can offer fast and effective service when we have problems with our lasers and this is something that we found that we can rely on very well with Coherent. That when problems do turn up, as they turn up inevitably, that they're resolved quickly and we have as little downtime in our experiments as possible.

—Dr. Michael Orger, Champalimaud Centre for the Unknown



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