



Product Information  
Version 2.0

## **ZEISS Lightsheet Z.1**

Light Sheet Fluorescence Microscopy  
for Multiview Imaging of Large Specimens



We make it visible.

# ZEISS Lightsheet Z.1: Be Amazed at Where Life Can Take You!

- › In Brief
- › The Advantages
- › The Applications
- › The System
- › Technology and Details
- › Service

## More Images. Gentle. Fast.

Discover the benefits of the first light sheet microscope designed to image fluorescently labeled living samples. Now you can observe your model organisms, tissues and cells as they develop over days with virtually no phototoxicity or bleaching. Lightsheet Z.1 lets you acquire images of your whole sample volume at sub-cellular resolution in a fraction of the time it takes with other techniques. Follow the development of your most valuable specimens in a gentle and stable environment – with up to a thousand times less light exposure.



*Spheroid after 8 days of formation, T470 H2B GFP labeling the nuclei. The spheroid was imaged with Lightsheet Z.1 detection optics 20x/1.0 (water immersion) from 8 different viewing angles. Multiview recording was registered and fused into one 3D dataset. Courtesy of N. Ansari, Buchmann Institute for Molecular Life Sciences, Goethe University Frankfurt, Germany*

# ZEISS Lightsheet Z.1: Simpler. More Intelligent. More Integrated.

- › In Brief
- › **The Advantages**
- › The Applications
- › The System
- › Technology and Details
- › Service

## Multiview Imaging of Multiple Samples

The coverslip-free sample preparation for Lightsheet Z.1 and Multiview imaging give you the unique opportunity to view your sample from any angle. Combining data from Multiview imaging improves the resolution and the information content of your images. Acquire Multiview datasets of your experiment samples and the control samples under the exact same conditions, in one timeseries. Or get higher throughput and collect data of multiple samples in one experiment. You can collect Z stacks from the perfect angle of viewing – or from a number of different angles, in multiple positions and with different zoom factors.

## Light Sheet Optics by ZEISS

Lightsheet Z.1 uses an innovative concept that combines cylindrical lens optics and laser scanning to generate the illumination light sheet. Use the patented Pivot Scan technology to get artifact free optical sections. With image zoom, precise light sheet alignment and a custom-built sample holder, this system has the stability to produce high quality images, with virtually no photo damage.

## Real Life

Light sheet fluorescence microscopy is the gentlest of all known optical sectioning techniques. Live samples can grow without being adversely affected by the excitation light. Multiple day experiments have become the new normal. We've created a special sample chamber that provides heating, cooling and CO<sub>2</sub> to maintain the perfect environment. Use pauses of image acquisition to trigger external devices. Control daylight illumination or a pump for culture media exchange to tend to the special needs of your sample.



**You Tube** *Reconstructed Multiview dataset of a mouse kidney (E15.5.), 5 views imaged with dual side illumination, Lightsheet Z.1 detection optics 5x/0.16, fused with the unique interactive registration of ZEN imaging software. The collecting duct system is labelled with anti-Troma antibody, secondary antibodies with Alexa Fluor 595. Sample: courtesy of R. Prunskaitė-Hyyryläinen, Biocenter Oulu, University of Oulu, Finland*

**You Tube** *Root growth in transgenic plant Arabidopsis thaliana, stably expressing an actin cytoskeleton marker. Maximum intensity projection from four different views with Lightsheet Z.1 detection optics 20x/1.0 (water immersion). Courtesy of M. Ovečka, Centre of Region Haná for Biotechnological and Agricultural Research, Palacký University Olomouc, Czech Republic.*

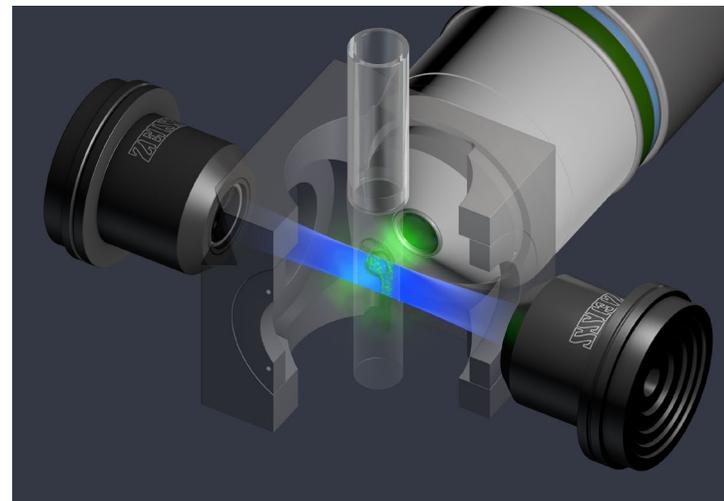
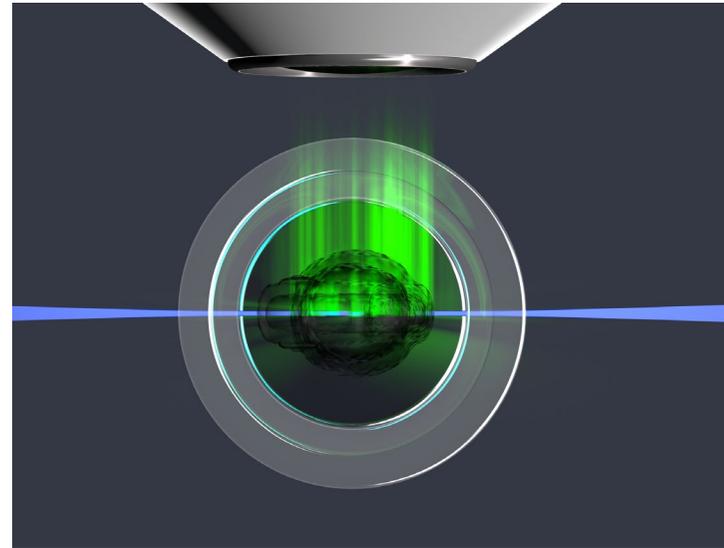
# Your Insight into the Technology Behind It

- › In Brief
- › **The Advantages**
- › The Applications
- › The System
- › Technology and Details
- › Service

## Maximum Photon Efficiency.

### Maximum Speed.

Light sheet fluorescence microscopy (LSFM) splits fluorescence excitation and detection into two separate light paths, with the axis of illumination perpendicular to the detection axis. That means you can illuminate a single thin section of the sample at one time, generating an inherent optical section by exciting only fluorescence from the in-focus plane. No pinhole or image processing is required. Light from the in-focus plane is collected on the pixels of a camera, rather than pixel by pixel as, for example, in confocal or other laser scanning microscopes. Parallelization of the image collection on a camera-based detector lets you collect images faster and with less excitation light than you would with many other microscope techniques. In summary, LSFM combines the optical sectioning effect with parallel image acquisition from the complete focal plane. This makes 3D imaging extremely fast and very light efficient.



# Your Insight into the Technology Behind It

- › In Brief
- › **The Advantages**
- › The Applications
- › The System
- › Technology and Details
- › Service

## The Patented Pivot Scanner

### Delivers Homogeneous Illumination

When the light sheet is passing through the sample, some structures of the specimen, e.g. nuclei, will absorb or scatter the excitation light. This will cast shadows along the illumination axis, as you see in Figure 1. This effect occurs in all fluorescence microscopes, but the illumination axis in light sheet fluorescence microscopy is perpendicular to the observation axis and so this effect is more obvious.

Lightsheet Z.1 is the only imaging system that can get rid of these shadows. A patented Pivot Scanner alters the angle of the light sheet upwards and downwards during image acquisition. By altering the illumination angle the shadows will be cast in different directions and excitation light will also reach region behind opaque structures, as you see in Figure 2.

### Without Pivot Scanner

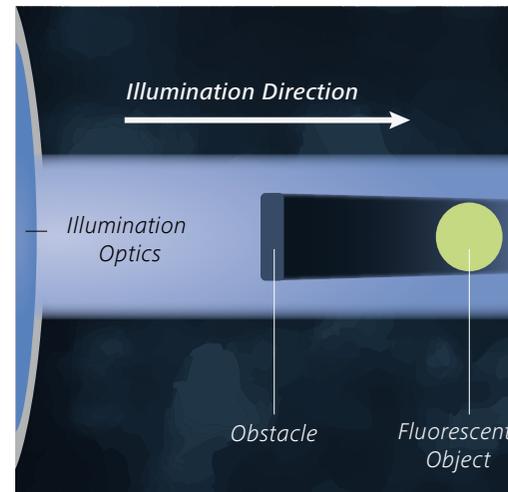
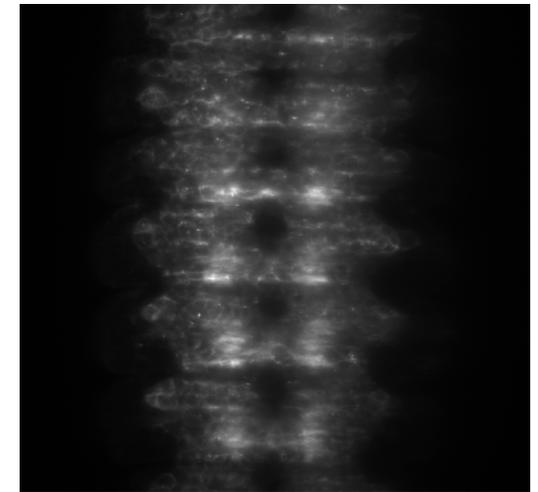


Figure 1



Ventral view of the central nervous system of a *Drosophila melanogaster* embryo.

### With Pivot Scanner

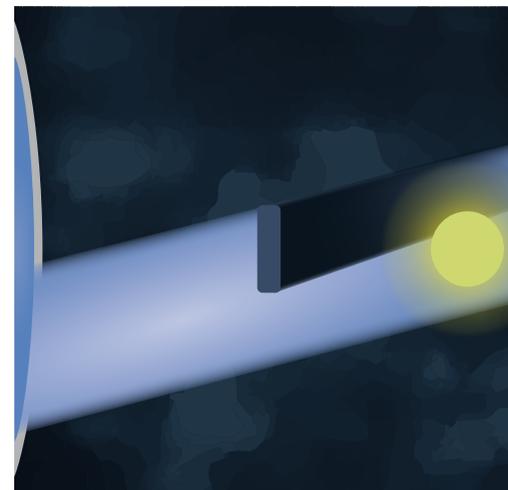
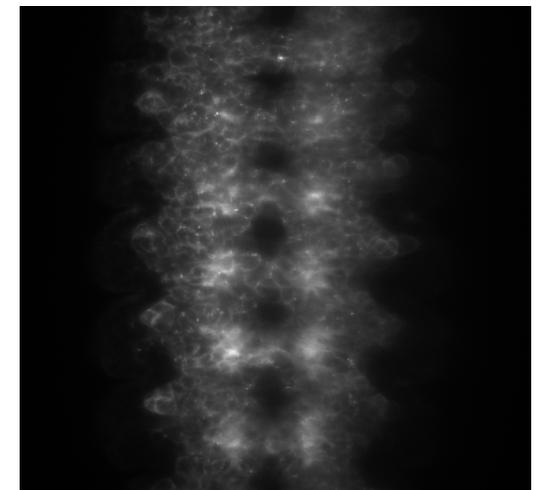


Figure 2



# Tailored Precisely to Your Applications

- › In Brief
- › The Advantages
- › **The Applications**
- › The System
- › Technology and Details
- › Service

Now you can perform experiments you would never have attempted before. Lightsheet Z.1 delivers unmatched speed in volume imaging. It's the gentlest way to observe the development of complete embryos of your model organism and to monitor the fastest physiological processes deep inside the specimen.

Typical Applications / Typical Samples	Task
<b>Morphogenesis and Embryogenesis in Developmental Biology and Systems Biology</b>	Fluorescence imaging of spatio-temporal patterns of gene expression, cell origin and migration, and organogenesis during embryogenesis. Ideal for use with a variety of organisms in developmental biology, providing you with complete imaging of samples such as <i>Drosophila melanogaster</i> , zebrafish, <i>C. elegans</i> and others.
<b>Organogenesis and Cell Dynamics</b>	Fast imaging of cellular dynamics in embryos and small organisms (cell migration, cardiac development, blood flow, vascular development, neuro-development, calcium imaging)
<b>3D Cell Culture</b>	Live imaging of 3D cell culture, spheroids and cysts, tissue culture, organotypic cultures. Analysis of, e.g., cell migration, expression patterns, cell proliferation.
<b>Plants</b>	Developmental processes, physiological measurements
<b>Imaging of Marine Organisms</b>	Fluorescence imaging of marine organisms (e.g., ciona, squid, plankton, flatworms)
<b>Structural Imaging of Fixed, Large (mm-sized) Specimens</b>	Fluorescence volume imaging of fixed specimens (e.g., early mouse embryos, zebrafish & medaka fish, tissue)
<b>Imaging of Optically Cleared Specimens *</b>	Imaging of fluorescently labeled fixed specimen (tissue sections, mouse brain, embryos, organs, spheroids and biopsies) that are optically cleared in aqueous clearing media such as Scale, CLARITY, FocusClear

\* A technical modification of Lightsheet Z.1 for imaging of cleared specimens is available upon request. Please contact us for more information.

# ZEISS Lightsheet Z.1 at Work

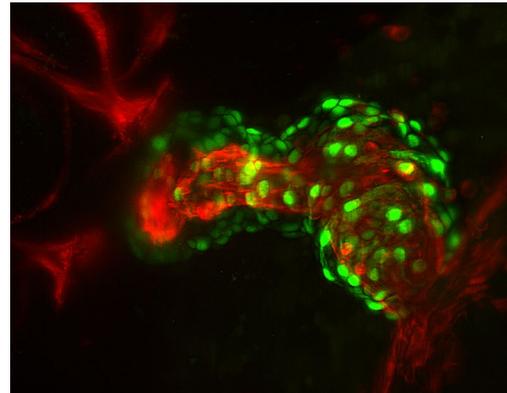
- › In Brief
- › The Advantages
- › **The Applications**
- › The System
- › Technology and Details
- › Service

## Zebrafish Heart Development

Light sheet fluorescence microscopy images with maximal frame rates of up to 80 fps with only minimal light exposure. This beating heart of a zebrafish larva was imaged with 68 fps. Labeled are the actin cytoskeleton (grey, LifeAct-GFP) and the nuclei (red, NLS-DsRed). The sarcomeres of the contractile apparatus with their z-bands are nicely identifiable. Both channels were acquired simultaneously at 28°C with Lightsheet Z.1 detection optics 20x/1.0 (water immersion).

## Zebrafish Heart

Maximum intensity projection of a 3D rendering of a 2-day old living zebrafish heart.



Courtesy of M. Mickoleit, Huisken Lab, MPI-CBG, Dresden, Germany

## Preserve Three-dimensional Structures

The symbiotic, marine anemone *Aiptasia* (fixed specimen) is an emerging model system for corals. Here, nuclei appear green and endosymbiotic dinoflagellates, marked by their autofluorescence, in red. The anemone was imaged from 6 different views with Lightsheet Z.1 detection optics 5x/0.16. This Multiview experiment was registered with fiducials as landmarks and fused to one 3D data-set with ZEN imaging software. The fluorescence channel with the fiducials was removed after processing.



Courtesy of S. Reischauer, MPI for Heart and Lung Research, Bad Nauheim, Germany



Specimen: courtesy of A. Guse, COS Heidelberg.

# ZEISS Lightsheet Z.1 at Work

- › In Brief
- › The Advantages
- › **The Applications**
- › The System
- › Technology and Details
- › Service

## Live Imaging of *Drosophila melanogaster*

Light sheet fluorescence microscopy images the complete development of a *Drosophila melanogaster* embryo with minimal light exposure, capturing the entire embryo volume within a time frame of only minutes. In this wild type embryo, the nuclear label is Histone-RFP. Lightsheet Z.1 allows live imaging from four angles every two minutes. Acquired with Lightsheet Z.1 detection optics 20x/1.0 (water immersion), 30 msec exposure time, excitation wavelength 561 nm, a total of over 400 timepoints.

 Data: courtesy of C. Staber, J. Zeitlinger, Stowers Institute for Medical Research, Kansas City, USA. The volume of the dataset is about 3 TB. Data reconstructed and processed for visualization with ZEN imaging software.

## Live Imaging of the Marine Amphipod *Parhyale hawaiiensis*

Live embryo of the marine amphipod *Parhyale hawaiiensis*, four angles. The movie shows a 3D rendering of a late embryo labeled with a nuclear red fluorescent protein (Histone2B-mRF-Pruby).

 Courtesy of A. Pavlopoulos and P. Tomancak, MPI-CBG, Dresden, Germany

## Image Large Samples in 3D

This entire 2-day old zebrafish was imaged from four angles and reconstructed using Multiview registration and fusion software. The fish expresses Tg (Bactin:H2A-mCherry) in the nuclei. The green channel shows autofluorescence.

 Sample: Courtesy of C. Hoppe, G. Shah, Huisken Lab, MPI-CBG, Dresden.

# ZEISS Lightsheet Z.1 at Work

- › In Brief
- › The Advantages
- › **The Applications**
- › The System
- › Technology and Details
- › Service

## Imaging Several Living Specimens in One Experiment

Three *Drosophila* embryos were imaged with the detection optics 20x/1.0, each from 4 viewing angles every 6 minutes for 15 hours.

The Multiview datasets were registered and fused into one 3D image using fiducials as landmarks; the channel with the fiducial signal was removed after registration. All embryos were embedded in 1 % low melting agarose and temperature was set to 25°C during the experiment. Image acquisition started before eYFP expression was visible and two of the *Drosophila* embryos showed expression of eYFP under control of the *Dfd* (deformed) enhancer during gastrulation (left: stage 10-14, right: stage 10–16/17). eYFP is visible from stage 11 onwards in the mandibular and maxillary segment of the head in the posterior spiracles and denticle belts from stage 13. Autofluorescence in the yolk allows following gastrulation; the yolk ends up in the gut lumen. The gut of the embryo on the right starts to form constrictions at the end of the movie. At this point (stage 16), embryogenesis is almost finished and the embryo starts to move.

## Long Term Imaging of Plants

Dynamic movement of cytoplasm in root cells of transgenic *Arabidopsis* plant, stably expressing GFP. The movie is a maximum intensity projection of Z-stacks taken over time.



*Samples: courtesy of J. Sellin, LIMES Institute Bonn, Germany*



*Samples: courtesy of J. Sellin, LIMES Institute Bonn, Germany*



*Sample: courtesy of M. Ovečka, Centre of Region Haná for Biotechnological and Agricultural Research, Palacký University, Czech Republic*

# ZEISS Lightsheet Z.1: Your Flexible Choice of Components

- › In Brief
- › The Advantages
- › The Applications
- › **The System**
- › Technology and Details
- › Service



## 1 Microscope

- Standalone sealed box system: laser safe, no eyepieces, Sample Chamber, Sample Holder
- Incubation and temperature control options (cooling and heating)
- CO<sub>2</sub>-Module

## 2 Objectives

- Lightsheet Z.1 detection optics 5x/0.16
- Lightsheet Z.1 detection optics 20x/1.0 (water immersion)
- Lightsheet Z.1 detection optics 40x/1.0 (water immersion)
- Lightsheet Z.1 detection optics 63x/1.0 (water immersion)

## 3 Illumination

- Illumination Optics Lightsheet Z.1 5x/0.1
- Illumination Optics Lightsheet Z.1 10x/0.2
- Flexible choice of laser lines: 405 nm, 445 nm, 488 nm, 515 nm, 561 nm, 638 nm
- Transmission LED for sample positioning and overview

## 4 Cameras

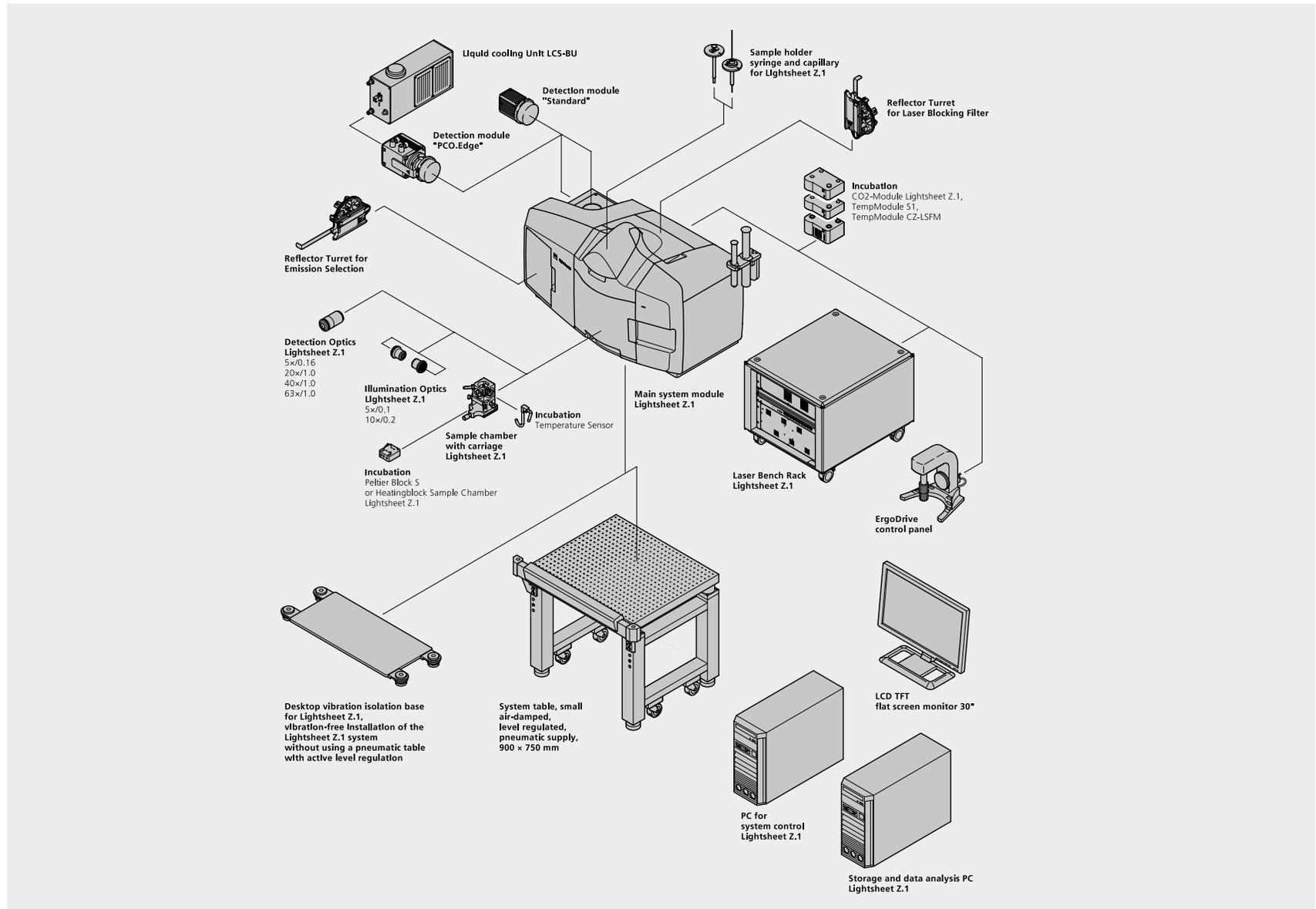
- Lightsheet Z.1 detection module "Standard"
- Lightsheet Z.1 detection module "PCO.Edge"
- Selected emission filters and beam splitters

## 5 Software

- ZEN 2014 for Lightsheet Z.1
- Lightsheet Z.1 Multiview Processing
- 3D VisArt
- Deconvolution

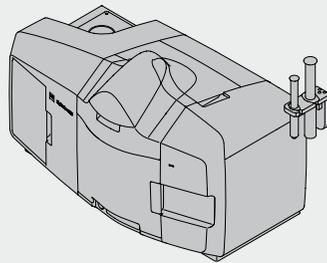
# ZEISS Lightsheet Z.1: System Overview

- › In Brief
- › The Advantages
- › The Applications
- › **The System**
- › Technology and Details
- › Service



# Technical Specifications

- › In Brief
- › The Advantages
- › The Applications
- › The System
- › **Technology and Details**
- › Service



Component	Description
Illumination Optics	Illumination Optics Lightsheet Z.1 5x/0.1
	Illumination Optics Lightsheet Z.1 10x/0.2
Illumination	Transmission LED for sample positioning and overview
	Flexible choice of laser lines: 405 nm, 445 nm, 488 nm, 515 nm, 561 nm, 638 nm at various output power levels
Detection Modules	Detection Module "Standard", ICX 285 CCD, 1388 × 1036 pixels
	Detection Module "PCO.Edge", sCMOS, 1920 × 1920 pixels (requires liquid cooling)
Detection Optics	Lightsheet Z.1 detection optics 5x/0.16
	Lightsheet Z.1 detection optics 20x/1.0 (water immersion)
	Lightsheet Z.1 detection optics 40x/1.0 (water immersion)
	Lightsheet Z.1 detection optics 63x/1.0 (water immersion)
Sample Chamber, Sample Holder, Consumables	Starter kits and all necessary accessories for your experiments
Software	Lightsheet Z.1 Multiview Processing
	3D VisArt
	Deconvolution
Data Storage Modules	8 TB Storage and Data Analysis Module
	32 TB Storage and Data Analysis Module
Incubation	Heating block Sample Chamber with controller TempModule S1
	Peltierblock Sample Chamber with Temperature Sensor with controller TempModule S1 and TempModule CZ-LSFM
	CO <sub>2</sub> -Module
	Heating Device Humidity
Trigger	Trigger-out signal via BNC connector. High level of 3.3 V (nominal value of the high level: > 3.2 V < 4.0 V, and nominal value of the low level: 0 V ±0.4 V). The minimal working resistance is 5 kΩ.

# Technical Specifications

- › In Brief
- › The Advantages
- › The Applications
- › The System
- › **Technology and Details**
- › Service

<b>Microscope</b>	Standalone box system, sealed, turnkey, laser safe, no eyepieces	
<b>Physical Dimensions</b>	<b>Approx. Width x Depth x Height</b>	<b>Approx. Weight</b>
Main System Module Lightsheet Z.1	800 mm x 450 mm x 500 mm	75 kg
Laser Rack "LB Rack Lightsheet"	600 mm x 700 mm x 550 mm	80 kg
System Table for main System Module Lightsheet Z.1, Level regulated	900 mm x 750 mm x 770 mm	90 kg
<b>Transmission Contrast for Overview</b>	IR LED illumination, no Köhler Illumination, not specified for high quality imaging	
<b>Spectral Range of Detection</b>	400 – 740 nm	
<b>Dual Camera Port for simultaneous 2 Channel Detection</b>		
<b>Detection zoom</b>	0.36x – 2.5x, continuous	For imaging, the zoom range of 0.7x – 2.5x is recommended, 0.36x – 0.7x for sample positioning only
<b>Field of View</b>	60 µm to 2.8 mm	2.8 mm image diagonal, 5x detection lens, zoom 0.7x, for sample positioning (zoom 0.36x) > 5 mm
<b>Embedded Specimen Size</b>	From < 1 µm to 5 mm	
<b>Sample Mounting</b>	Dedicated sample holder and sample chamber for live imaging of mm-sized specimen	
<b>Immersion and Incubation Media</b>	Sample chamber and optics designed for aqueous media	
<b>Light sheet thickness</b>	2 µm – approx. 14 µm	Depending on sample, at 488 nm

# Technical Specifications

- › In Brief
- › The Advantages
- › The Applications
- › The System
- › **Technology and Details**
- › Service

<b>Detection Modules</b>	Up to two detection modules of the same type can be connected to the dual camera port		
<b>Detection Module "Standard"</b>	CCD based on Sony ICX 285 sensor, aligned on a special C-mount for optimized image alignment on dual camera port		
	Pixel size	6.45 µm	
	Max. pixel format	1388 x 1036	
	Bit depth	14 bit	
	Max. frame rate	> 10 fps full frame, in continuous z-drive mode	
<b>Detection Module "PCO.Edge"</b>	sCMOS sensor, requires liquid cooling, aligned on a special C-mount for optimized image alignment on dual camera port		
	Pixel size	6.5 µm	
	Max. pixel format	1920 x 1920 (3.7 Mpixel)	
	Bit depth	15 bit	
	Max. frame rate	30 fps at 1000 x 1000 pixel, in continuous z-drive mode	
<b>Data Acquisition Rate</b>	With dedicated Lightsheet Z.1 storage module	Up to 150 Mbyte/sec	
<b>Incubation</b>			
<b>Heating Block</b>	Heating of sample chamber medium	Room temperature to 42 °C	0.5 °/min
<b>Peltier Block</b>	Heating and cooling of sample chamber	10 °C to 42 °C	Up to 1.5 °/min heating, up to 1.0 °/min cooling
<b>Temperature Stability</b>	± 0.1 °C		
<b>CO<sub>2</sub>-Module</b>	Requires CO <sub>2</sub> supply, adjustable concentration		0 % to 10 %

# Technical Specifications

- › In Brief
- › The Advantages
- › The Applications
- › The System
- › **Technology and Details**
- › Service

<b>Sample Positioning</b>	Four-axis multi-coordinate stage with stepper motors	Specifications: x / y / z / $\alpha$
Travel Range		10 mm / 50 mm / 10 mm / 360°
Reproducibility ( $\pm$ )		200 nm / 650 nm / 200 nm / 0.1°
Smallest Increment		50 nm / 1 $\mu$ m / 50 nm / 0.05°
Speed of Rotation Motor		90° / sec
Max. z Travel Rate		2 mm / sec
<b>Laser Module</b>		
Laser Class	All Lasers are class 3B The installed system as a whole is laser class 1	
Laser Wavelengths and Power (Power: pre-Fiber)	405 nm	20 mW or 50 mW
	445 nm	25 mW or 40 mW
	488 nm	30 mW, 50 mW or 100 mW
	515 nm	20 mW or 50 mW
	561 nm	20 mW, 50 mW or 75 mW
	638 nm	75 mW



# Technical Specifications

- › In Brief
- › The Advantages
- › The Applications
- › The System
- › **Technology and Details**
- › Service

Environmental Conditions			
Operation	Permissible ambient temperature (specified performance)	22 °C ± 3 °C	(Constant, if fluctuating, warm-up time applies)
	Permissible ambient temperature (reduced performance)	15 °C to 35 °C	
	Permissible relative air humidity (no condensation)	< 65 % at 30 °C	
	Max. altitude of installation site	Max. 2000 m	
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Warm-up Time	60 min	For high precision and/or long-term measurements ≥ 3 h	
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Vibrations	To be operated in conformance with Vibration Class C. VC-C, 12,5 µm/s RMS amplitude of frequency band 8 – 80 Hz (RMS = root mean square) according to ISO 10811.		
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Electrics and Power			
Mains Voltage		220 V AC to 240 V AC (±10 %)	100 V AC to 125 V AC (±10 %)
Supply Frequency		50 to 60 Hz	50 to 60 Hz
Lightsheet Z.1 System	Max. current	Single 3.5 A phase	Single 8 A phase
	Power consumption	800 VA max.	750 VA max.
Data Analysis PC	Power consumption	600 VA max.	600 VA max.
Protection Class / Protection Type		I / IP 20	
Overvoltage Category		II	
EMC Inspection		According to DIN EN 61326-1 (10/2006)	
Emitted Interference		According to CISPR 11/DIN EN 55011 (05/2010)	
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Heat Loss			
System Lightsheet Z.1 (incl. Lasers and Accessories)		700 W	
Data Analysis PC		600 W	
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Patents which apply for Lightsheet Z.1		US6037583, US6392796, US7554725, US7787179, US8214561, EP1576404	

# Count on Service in the True Sense of the Word

- › In Brief
- › The Advantages
- › The Applications
- › The System
- › Technology and Details
- › **Service**

Because the ZEISS microscope system is one of your most important tools, we make sure it is always ready to perform. What's more, we'll see to it that you are employing all the options that get the best from your microscope. You can choose from a range of service products, each delivered by highly qualified ZEISS specialists who will support you long beyond the purchase of your system. Our aim is to enable you to experience those special moments that inspire your work.

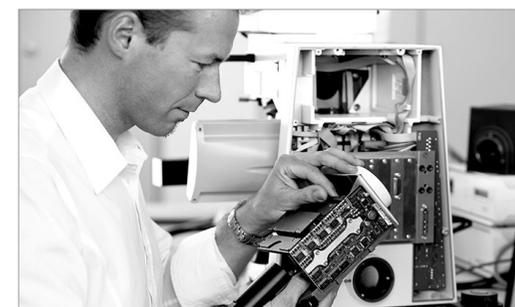
## **Repair. Maintain. Optimize.**

Attain maximum uptime with your microscope. A ZEISS Protect Service Agreement lets you budget for operating costs, all the while reducing costly downtime and achieving the best results through the improved performance of your system. Choose from service agreements designed to give you a range of options and control levels. We'll work with you to select the service program that addresses your system needs and usage requirements, in line with your organization's standard practices.

Our service on-demand also brings you distinct advantages. ZEISS service staff will analyze issues at hand and resolve them – whether using remote maintenance software or working on site.

## **Enhance Your Microscope System.**

Your ZEISS microscope system is designed for a variety of updates: open interfaces allow you to maintain a high technological level at all times. As a result you'll work more efficiently now, while extending the productive lifetime of your microscope as new update possibilities come on stream.



*Profit from the optimized performance of your microscope system with services from ZEISS – now and for years to come.*

>> [www.zeiss.com/microservice](http://www.zeiss.com/microservice)

The moment your data change scientific minds.  
**This is the moment we work for.**

- › In Brief
- › The Advantages
- › The Applications
- › The System
- › Technology and Details
- › Service



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MADE BY ZEISS



**Carl Zeiss Microscopy GmbH**  
07745 Jena, Germany  
BioSciences  
microscopy@zeiss.com  
www.zeiss.com/lightsheet



We make it visible.