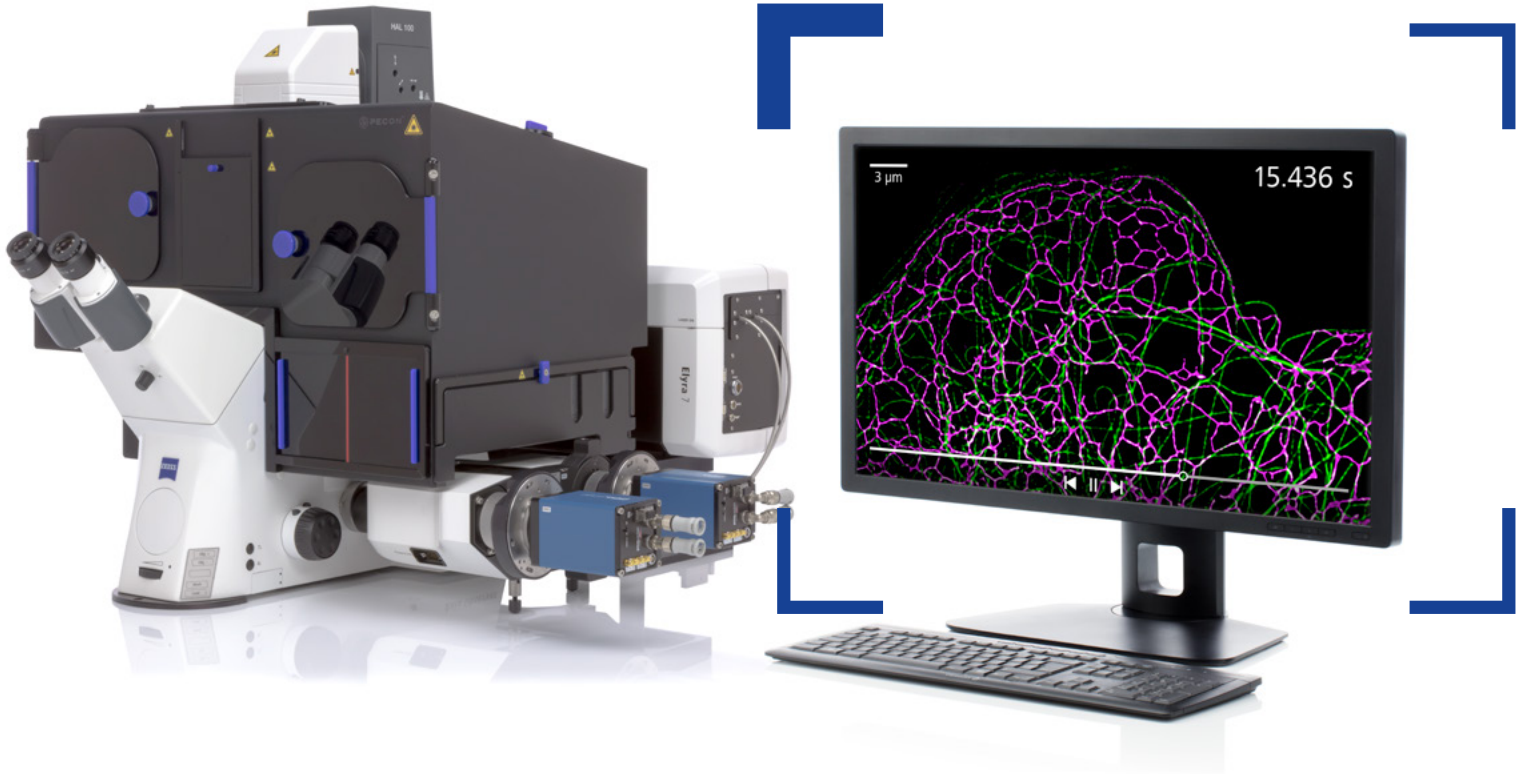
Revealing the vibrant sub-organelle network of life



ZEISS Elyra 7 with Lattice SIM²

Your Live Imaging System with Unprecedented Resolution

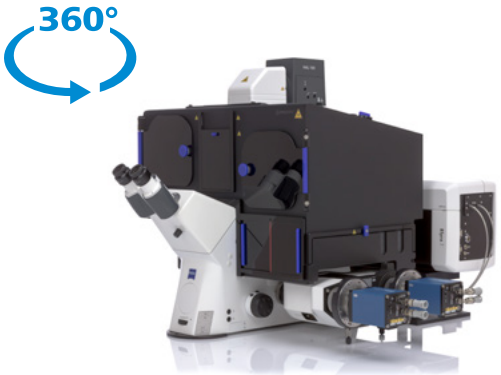
ZEISS

Seeing beyond

zeiss.com/elyra

Elyra 7 with Lattice SIM² and SIM² Apotome: high speed meets super-resolution imaging

It is common sense in modern Life Sciences that understanding the structure of a biological entity – be it a macromolecule, an organelle, a cell, or an organism – is key to understanding its function. For rigid structures, only spatial resolution matters, but for dynamic structures, higher acquisition speed and low-light conditions become inescapable necessities to achieve the required temporal resolution while also protecting the living samples.

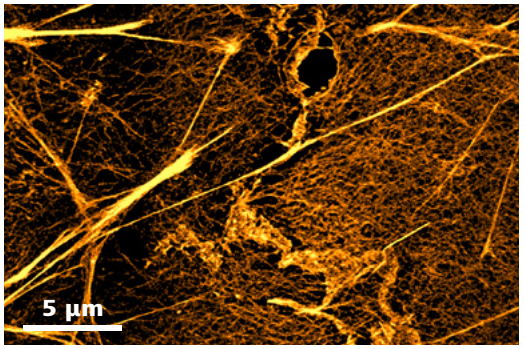


But must you sacrifice resolution when imaging at high speed using only the minimal exposure needed for life observation? Not necessarily! With its capability to double the resolution of conventional structured illumination microscopy (SIM), Lattice SIM² lets you reconstruct the finest details in images acquired under such demanding conditions. With SIM² Apotome, even lossless super-resolution imaging becomes possible, meaning a one-to-one ratio of raw to reconstructed images has become reality – all with superb out-of-focus light suppression and sectioning capability.

All benefits you enjoyed previously from both Lattice SIM and SIM Apotome are preserved in their SIM² successors. So, while achieving doubled resolution, you can still use standard dyes and fluorescent proteins, access simultaneous dual color imaging with even better separation between differently labeled structures and have large fields of view available if needed. Imaging modalities like Burst and Leap modes can be combined seamlessly with no further restrictions. And, Lattice SIM² can be combined on demand with TIRF, SIM, SMLM and Airyscan imaging on the Elyra 7 platform.

Simpler. More Intelligent. More Integrated.

Resolution excellence with Lattice SIM²
With SIM², a novel image reconstruction algorithm raising the SIM technology to a new level, you make the best use of the available photon budget. You can now double the conventional SIM resolution and discriminate the finest subcellular structures, even those no more than 60 nm apart. Lattice SIM² comes with outstanding out-of-focus light suppression, giving you the sharpest sectioning in wide-field microscopy even for highly scattering samples. SIM² image reconstruction robustly reconstructs all structured-illumination-based acquisition data of your Elyra 7 – with minimal artefacts – for living and fixed samples.

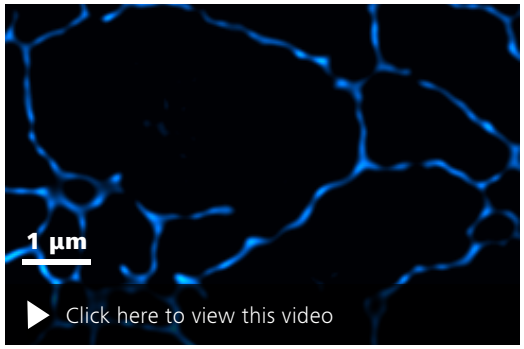


The Lattice SIM² image of Cos-7 cells labeled with phalloidin Alexa 488 shows the fine structure of the Actin network. Maximum intensity projection of Z stack is shown.

Speed and efficiency for your experiments
While doubling the classic SIM resolution, the light-efficient Lattice SIM² gives you gentle imaging of living and fixed specimens at high speeds of up to 255 fps.

Combine Lattice SIM² and SIM² Apotome with Burst and Leap modes to make super-resolution acquisition faster than ever before. With SIM Apotome mode, even lossless acquisition can be achieved, meaning for every reconstructed image just one raw image is needed!

Or make use of Elyra 7 Duolink to image two differently stained structures simultaneously and use the multiple colors to boost resolution even further.

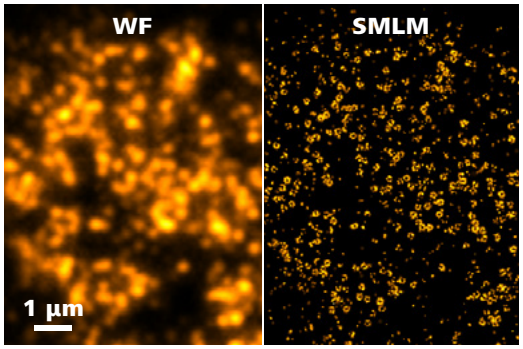


Lattice SIM²: Time lapse imaging of the endoplasmic reticulum (Calreticulin-tdTomato) in a Cos-7 cell reveals highly dynamic structural changes.

Flexibility for your research
Elyra 7 handles virtually all types of samples, including photo-sensitive cell cultures, scattering *C. elegans* and plants or tissue sections of up to 100 µm thickness.

Elyra 7 includes several microscopy techniques: Lattice SIM², SIM² Apotome, widefield DIC, SMLM and TIRF. You can correlate images of the same sample acquired using any or all of all these techniques to multiply the insights from your specimen.

You can even combine Elyra 7 with a variety of other imaging systems such as LSM with Airyscan or scanning electron microscopy in a correlative workflow.



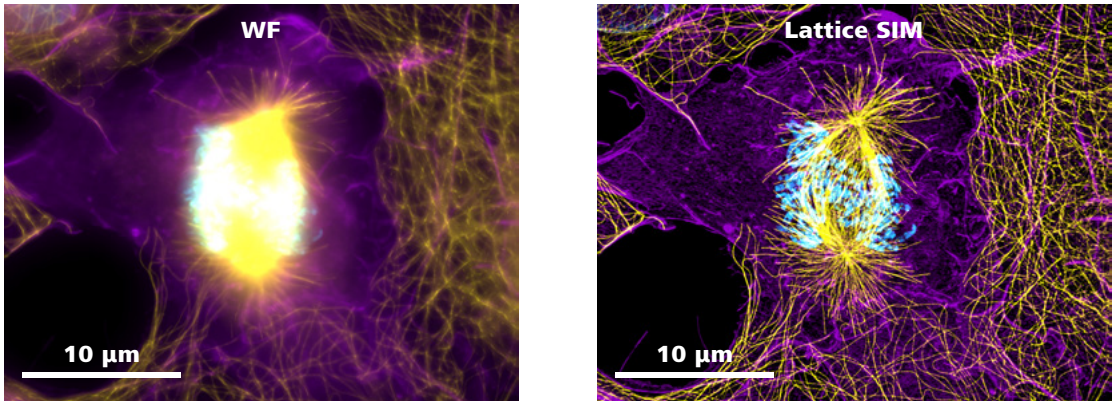
SMLM: Xenopus laevis A6 cells (epithelial kidney cells). Gp120, a nuclear pore complex protein arranged with eightfold symmetry was labeled with Alexa Fluor 647.

Your Insight into the Technology Behind It

Lattice SIM:
Your 3D super-resolution technique

In classic SIM, the sample area is illuminated and imaged with a grid. The grid structures interfere with structures in the sample, creating Moiré fringes. These fringes contain high frequency information – that is, high resolution information – transformed down to low frequencies that can be resolved by the microscope. To achieve this effect in all directions, the sample is imaged at different rotational and translational positions (phases) of the grid pattern. The phase images are deconvolved into the resulting image, which will have twice the resolution in all three dimensions.
In Lattice SIM, the sample area is illuminated with a lattice spot pattern instead of grid lines. Due to its intrinsic two-dimensionality, the lattice pattern requires only translational repositioning but no rotation. This leads to a dramatic increase in imaging speed. In addition, the lattice pattern provides higher contrast to allow a more robust image reconstruction. Since the sampling efficiency of lattice pattern illumination is 2× higher compared to classic SIM, you need less laser dosage for sample illumination. This lattice illumination makes SIM a preferred live cell imaging technique.
The strongly improved photon efficiency of lattice illumination allows you to increase the imaging speed while achieving higher contrast and lower photo dosage.

Watch the movie for a quick comparison of classic SIM and Lattice SIM



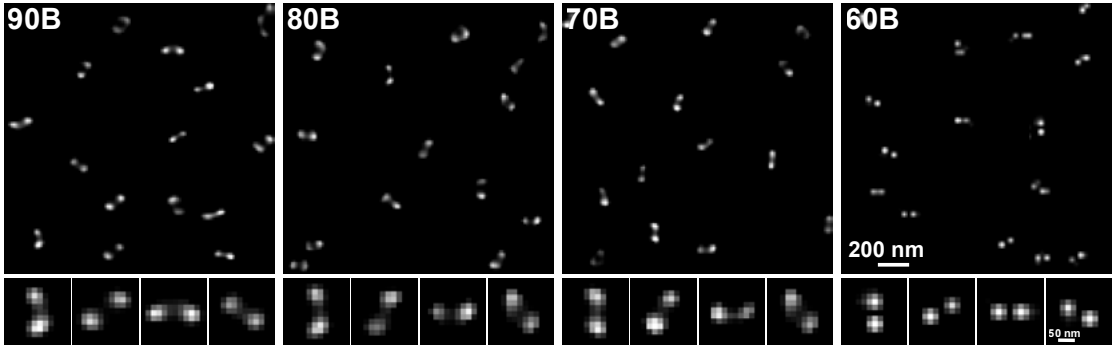
Lattice SIM: Comparison of widefield and Lattice SIM images of a Cos-7 cell undergoing mitosis stained for actin (Phalloidin Alexa Fluor 568, magenta), microtubules (anti-beta-tubulin Alexa Fluor 488, yellow) and nucleus (Hoechst, blue). Images are maximum intensity projections of 30 planes of a total depth of 3.19 µm. Objective: Plan-Apochromat 63×/1.4 Oil

Your Insight into the Technology Behind It

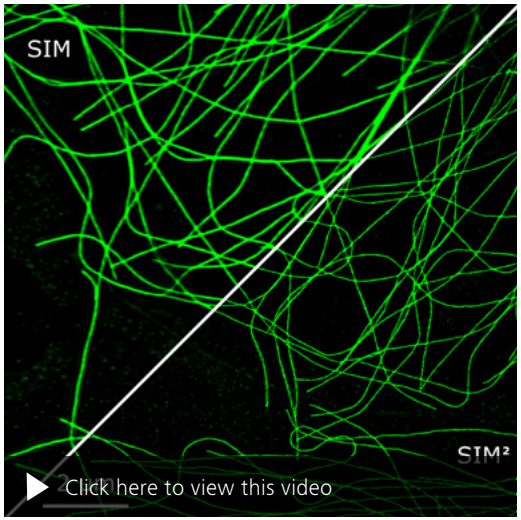
SIM² reconstruction:
Double your SIM resolution

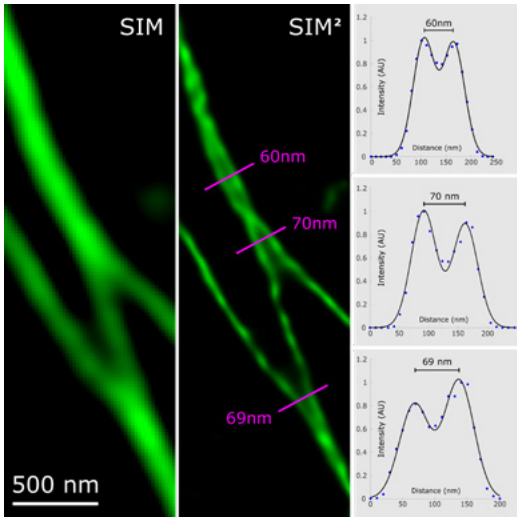
Dual-iterative SIM or SIM² is the novel, groundbreaking image reconstruction algorithm that increases the resolution and sectioning quality of structured illumination microscopy data. SIM² is compatible with all SIM imaging modes of your Elyra 7 and fully integrated in the ZEN software.

Unlike conventional reconstruction algorithms, SIM² is a two-step image reconstruction algorithm. First, order combination, denoising and frequency suppression filtering are performed. All the effects resulting from these digital image manipulations are translated into a digital SIM point spread function (PSF). The subsequent iterative deconvolution uses this very PSF. Similar to advantages of using experimental PSF for deconvolution of hardware-based microscopy data, the SIM² algorithm is superior to conventional one-step image reconstruction methods in terms of resolution, sectioning and robustness.



GATTA-STED Nanoruler 90B, 80B, 70B and 60B (GATTAquant, Germany) were imaged and processed with Elyra 7 Lattice SIM² mode with a 63×/1.4 oil objective. Distances of 90 nm, 80 nm, 70 nm and 60 nm are resolved.





Images of Cos-7 cell stained with anti-alpha-Tubulin Alexa fluor 488 were processed with the conventional SIM algorithms based on generalized Wiener filter and with the novel SIM² reconstruction. The images show an improvement of resolution for SIM² compared to SIM. The superior sectioning capability of SIM² is shown in the movie. Objective: Plan-Apochromat 63×/1.4 Oil

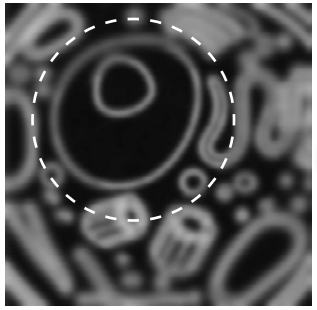
Your Insight into the Technology Behind It

SIM Apotome:
Flexible optical sectioning

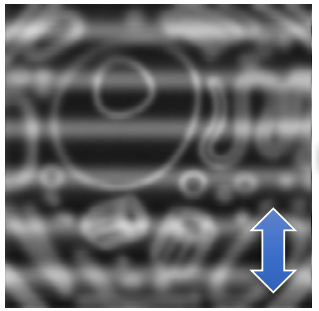
You know the challenge: Live cell imaging with a widefield system often suffers from out-of-focus blur or background signal. These effects can decrease contrast and resolution of your images. The SIM Apotome acquisition mode of Elyra 7 uses structured illumination to give you fast optical sectioning with crisp contrast and high lateral and axial resolution.

A grid pattern is used to illuminate and rapidly modulate the fluorescence signals in the focal plane of your microscope. After acquiring three or five images with different grid positions (phases), the ZEN imaging software combines these frames into a resulting image which contains only information from the focal plane – your optical section.

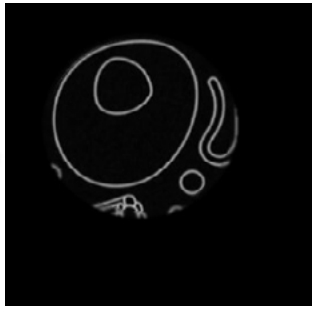
The SIM Apotome acquisition mode in combination with the SIM² reconstruction algorithm now allows you to further tune the gentleness of your fast live-cell imaging with high contrast and resolution. Or use your new optical sectioning speed to increase your productivity when acquiring large sample areas or large volumes at different magnifications.



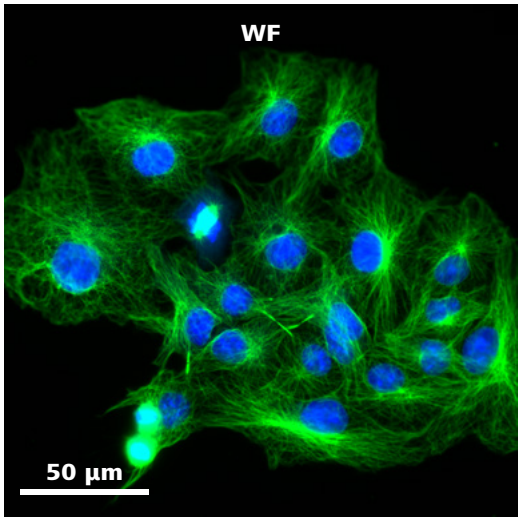
Widefield image with out-of-focus light. Signal from the focal plane is encircled by a white dashed line.



SIM Apotome acquisition at 3 or 5 different grid positions



Reconstructed optically sectioned image



SIM² Apotome: Comparison of widefield and SIM² Apotome single plane images of Cos-7 cells stained for microtubules (anti-alpha-tubulin Alexa Fluor 488, green) and nuclei (Hoechst, blue). Objective: LD LCI Plan-Apochromat 25× / 0.8 Imm Corr

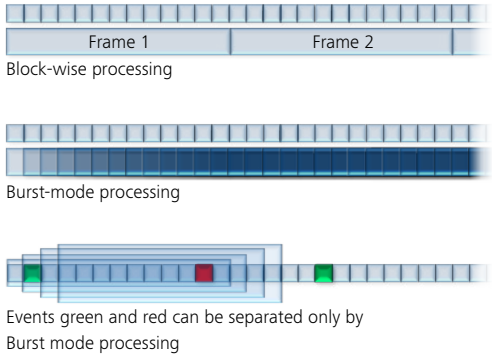
Your Insight into the Technology Behind It

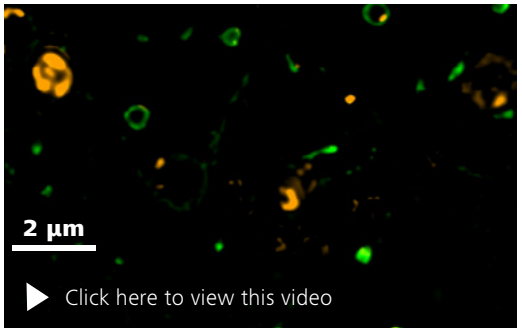
Boost the speed of SIM imaging even further

Elyra 7 already provides you with fast imaging speeds. But you can further increase the temporal resolution and productivity for 2D and 3D imaging by using the speed enhancement modes. The Burst mode and the Leap mode are compatible with Lattice SIM as well as SIM Apotome acquisition. Combined with SIM² image reconstruction, they enable you to capture highly dynamic processes at exceptional resolution in all three dimensions.

2D Burst mode:
Get full temporal information

Burst mode processing uses the rolling window approach to let you observe processes in your living samples at up to 255 fps. Since Burst mode is an image reconstruction feature as well, you have the flexibility to use it with already acquired data sets. You decide how much time information is required for your data analysis.

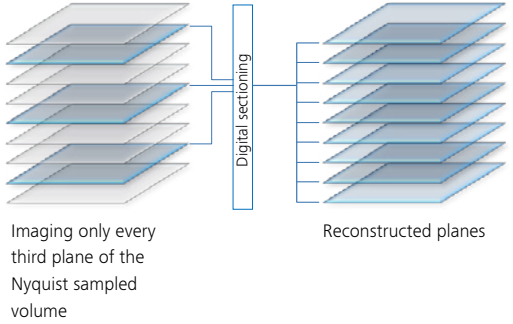


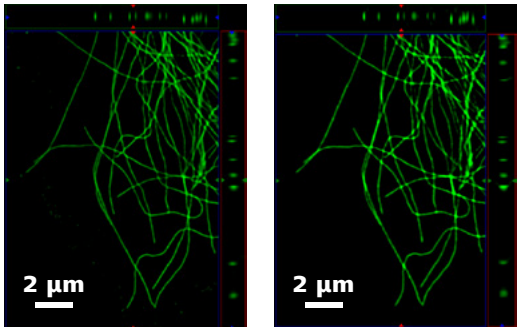


U2OS cell expressing an Rab5-mEmerald (green) and tdTomato tagged Golgi associated transport marker (orange). Simultaneous dual-color acquisition. Objective: Plan-Apochromat 63×/1.4 Oil

3D Leap mode:
Digital sectioning at a new level

Your research often demands fast imaging in 3D. The Leap mode acquisition enables you to reduce your imaging time and even lower the photo dosage for your sample. You simply image only every third plane and ZEN reconstructs the entire volume using a pixel reassignment approach.





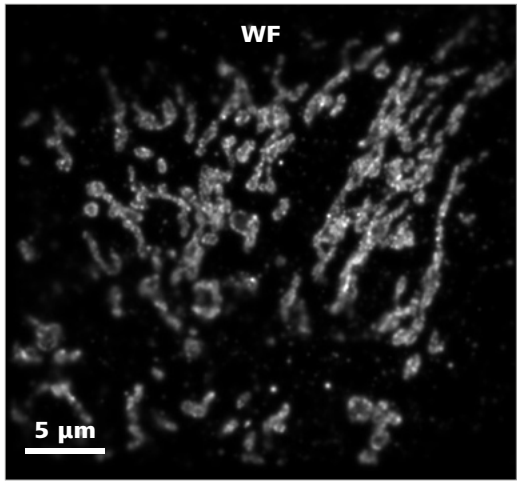
Cos-7 cells stained with anti-beta-tubulin Alexa Fluor 488. Images show XY, XZ and YZ view of the cropped volume image for Nyquist sampled (left) and digitally sectioned (right) images of the same sample area. Objective: Plan-Apochromat 63×/1.4 Oil

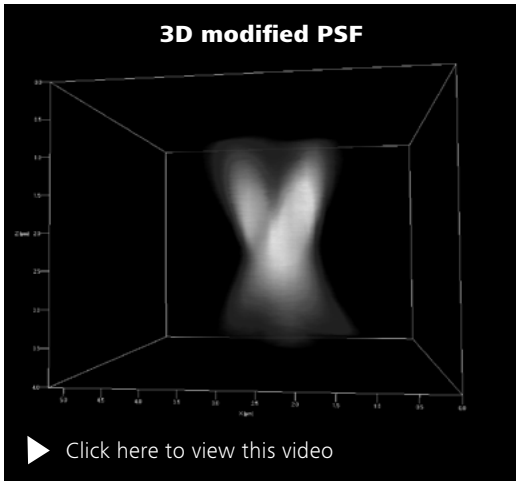
Expand Your Possibilities

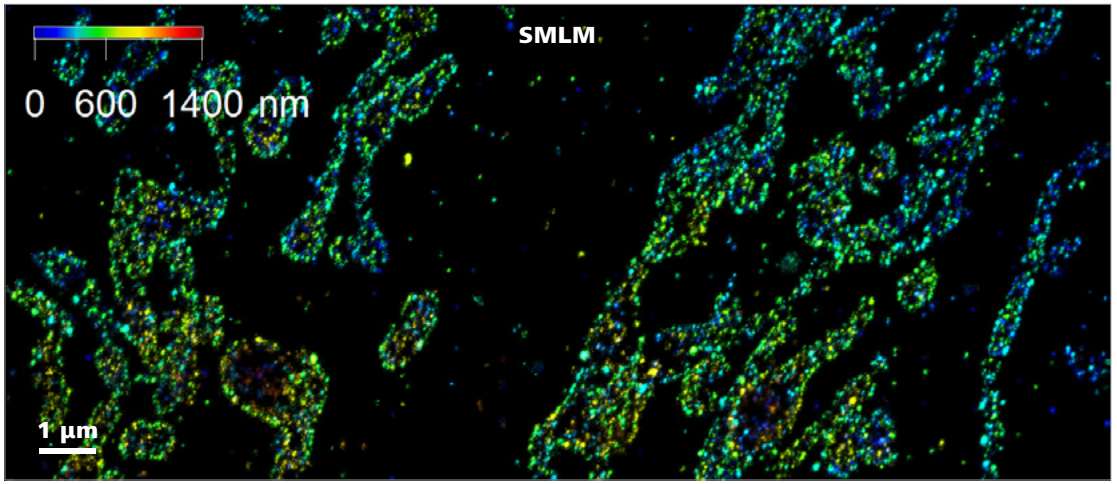
SMLM:
3D imaging at molecular resolution

In single-molecule localization microscopy (SMLM), fluorescent molecules are sparsely activated so that only one out of many will be in its on-state within a single point spread function (PSF). This lets you determine its center of mass with a localization precision that far exceeds the extension of the PSF. Once recorded, the molecule is turned to its off-state and the cycle of activation/deactivation is repeated until all molecules are captured. The localizations are plotted in a new image to create the super-resolution image. With Elyra 7 you can use SMLM techniques such as PALM, dSTORM and PAINT to achieve lateral resolution of 20–30 nm. The ZEN software will seamlessly perform the image reconstruction of your data.

In addition, Elyra 7 provides you with 3D SMLM mode based on PRILM technology. The PSF is reshaped for encoding the Z position so while acquiring only one plane, you get volume information of 1.4 µm depth at 50–80 nm axial resolution. Thus, you can acquire 3D data from a whole cell with consistent molecular precision.







3D PAINT image of mitochondrial membranes in BSC1 (kidney epithelial cells). The outer membrane protein Tomm20 was labeled using Ultivue – I2-650 imaging strand. Reshaped PSF encoding for Z information was used to create a 1.4 µm deep 3D PAINT image. Upper figures show the widefield microscopy image (left) of the area as well as the 3D image of the modified PSF (right) used for 3D SMLM. Objective: alpha Plan-Apochromat 63×/1.46 Oil

Expand Your Possibilities

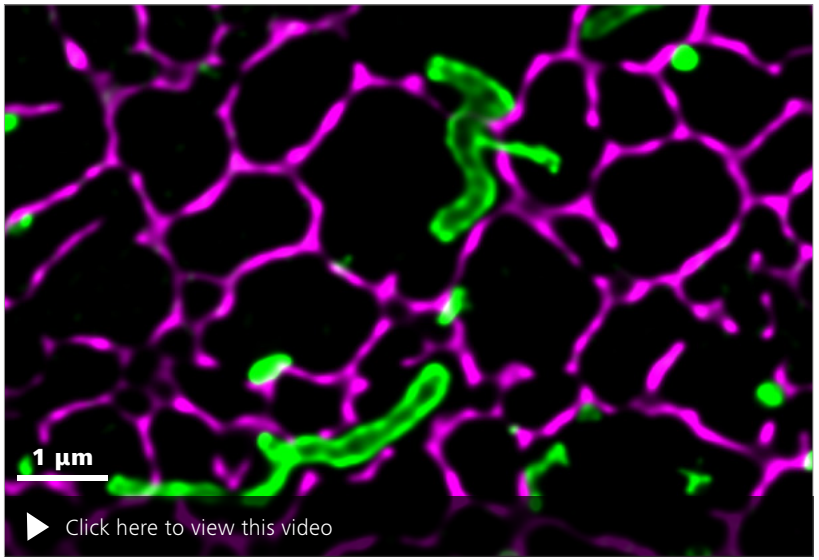
Elyra 7 Duolink: Simultaneous two-color imaging

Investigation of living samples very often focuses on interactions of different proteins or organelles. Simultaneous imaging of the involved structures is key to proper understanding of these highly dynamic processes.

Equip your Elyra 7 with a Duolink adapter to operate two sCMOS cameras and use all the advantages that a widefield-based technology can offer:

- Perform true simultaneous two-color imaging within your entire field of view – without any delays within the image such as can occur when using scanning-based technologies or during consecutive data acquisition of different channels.
- Acquire a super-resolved real-time snapshot of an entire living cell by picking a low exposure time.
- Increase the productivity of your fixed cell experiments by doubling the amount of information gained during the same amount of time.
- Image any possible color combination with the two cameras, and with minimal signal crosstalk as enabled by the integrated multi-bandpass emission filters.
- Acquire 4-color images without the need for mechanical filter change – making your multi-color experiments even faster.
- Perform multi-color SMLM experiments on the two sCMOS cameras.

Elyra 7 Duolink sCMOS camera adapter for simultaneous two-color acquisition with integrated multi-bandpass emission filter cubes for efficient image acquisition



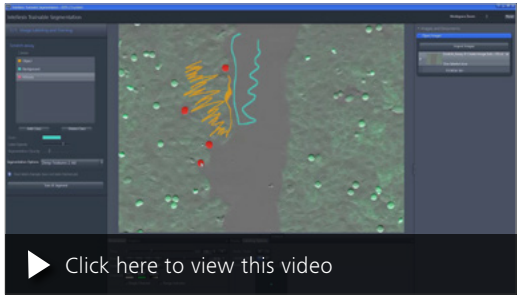
Cos-7 cell expressing the endoplasmic reticulum marker Calreticulin-tdTomato (magenta) and mitochondrial marker Tomm20-mEmerald (green) was simultaneously imaged for two colors. The movie shows high dynamic interactions of the ER and mitochondria. Objective: Plan-Apochromat 63×/1.4 Oil

Expand Your Possibilities

Translate your images into quantitative data

ZEISS ZEN

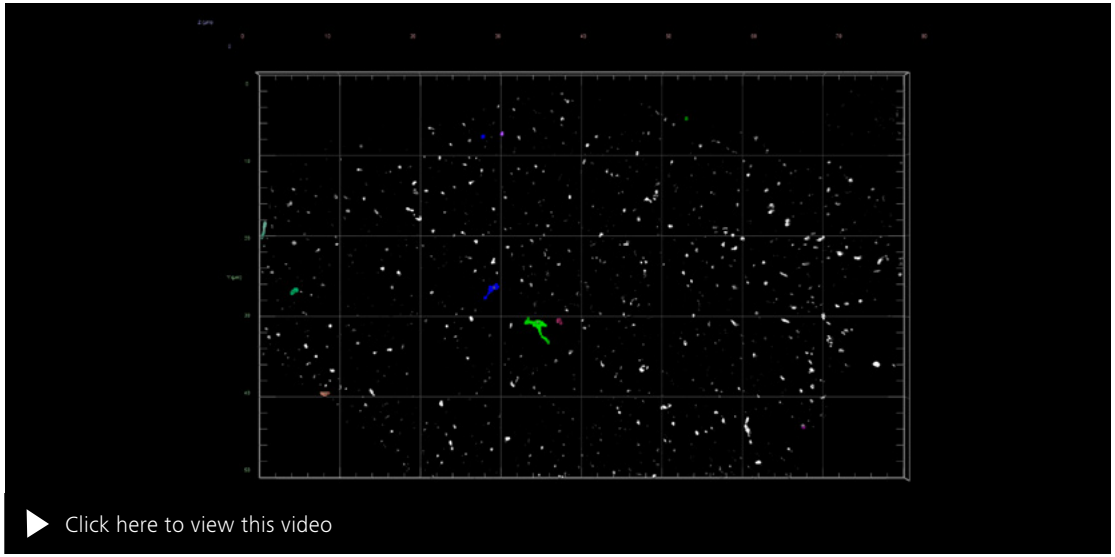
ZEN software is your pathway from images to quantitative results ready for publication. The .czi file format stores all required acquisition parameters as openly accessible metadata. Furthermore, ZEN software provides you with a variety of different image pre- and post-processing tools. For example, you can take advantage of machine learning based on the ZEN Intellesis module to segment complex image data in an easy and intuitive way. Use the ZEN Analysis functionality to quantify geometric features, as well as complex structural interactions in your sample and even create the relevant plots and histograms.



ZEN Intellesis is a user-friendly machine learning based software module providing excellent image segmentation results. It is fully integrated in ZEN image analysis workflows.

arivis Vision4D®

Use the efficient arivis Vision4D® software for visualization and quantification of large 3D and 4D data sets imaged with your Elyra 7. arivis Vision4D® is able to not only render volume images of almost unlimited size but also provides advanced image processing tools such as volume fusion, channel shift, conventional and machine learning based segmentation and 3D tracking. Visualize your quantitative results within the arivis Vision4D® software or export all data for further analysis. The modular structure of arivis Vision4D® flexibly adjusts to your needs for advanced image processing and analysis.



U2OS cells expressing the endosomal marker Rab5-mEmerald were imaged in Lattice SIM 3D Leap acquisition mode over time. The Lattice SIM² data set was transferred to arivis Vision4D® software for segmentation and tracking of the endosomes. Objective: Plan-Apochromat 63×/1.4 Oil

Tailored Precisely to Your Applications

Typical applications, typical samples	Task	ZEISS Elyra 7 offers
Live cell Imaging	Reveal mechanistic details in live cells, e.g. moving organelles, vesicle trafficking, membrane reorganization	Lattice SIM allows fast, gentle and light-efficient imaging.
		Lattice SIM: One-pass image acquisition over the full FOV (rather than multiple rotations) increases speed and reduces laser dosage.
		Lattice SIM / SMLM: Samples stay in focus over time with Definite Focus 3.
	Resolve structural details in 3D and multiple colors.	Lattice SIM: Digital sectioning allows faster acquisition by reducing the number of z-slices while preserving the optical sectioning capability.
		Lattice SIM / SMLM: Acquire two channels simultaneously and up to four colors (Lattice SIM²) with optimized resolution for each wavelength. Duolink and optimized filter concept allow fast and aligned multiple-channel acquisition.
	Discover fast cellular processes in the context of whole cells.	Lattice SIM: Large FOV to capture a whole cell in one image.
	Observe fast dynamics of fine structures without perturbing the specimen.	Lattice SIM: Light-efficient illumination enables gentle observation of fast dynamics.
		Incubation: Fully integrated incubation controls, temperature optimized oils, water immersion objective with correction collar.
	Track many molecules and retrieve diffusion behavior.	SMLM: Particle tracking over a large FOV allows for collection of diffusion information in entire cells. Camera limited temporal resolution.
	Study molecular level structural changes of sub-minute-scale dynamic processes, e.g. mechanisms of focal adhesions, reorganization of tubulin, vesicle shuttling.	SMLM: Powerful lasers across the visible spectrum and multi-emitter analysis reduce acquisition times and allow measurement of dynamics on the sub-minute timescale.
	Perform not only superresolution but also conventional live-cell imaging experiments such as recording membrane dynamics, cell division, cell migration.	SIM Apotome: An unique combination of excellent optical sectioning and imaging speed for broad range of objectives. Digital sectioning can be used for even faster volume imaging. TIRF and conventional widefield fluorescence microscopy provide versatility.
Large evolving organisms, such as *Drosophila, C. elegans, Arabidopsis*, Zebrafish, etc.	Resolve structural detail in 3D with high penetration depth.	Lattice SIM: Water objectives for deep tissue imaging.
		Benefit from additional options such as optical sectioning, DIC, phase contrast.
		SIM Apotome mode for fast optical sectioning.
	Resolve structural details in 3D over large areas.	Lattice SIM: Tiling and stitching to cover large areas; level-adjustable stage to avoid sample tilt.

Tailored Precisely to Your Applications

Typical applications, typical samples	Task	ZEISS Elyra 7 offers
Fixed specimens	Probe the structural organization of a whole cell with the advantage of fluorescence specificity and superresolution.	Lattice SIM: Large FOV to captures a whole cell in one image. Lattice SIM provides faster acquisition speed for higher throughput.
	Investigate arrangement of cellular components and proteins.	Lattice SIM: Adapted grating, acquires four colors with optimized resolution for each wavelength.
	Explore interaction of molecules.	Lattice SIM / SMLM: Drift compensation and adaptive color alignment of all channels.
	Reveal the ultrastructure of organelles.	3D-SMLM: Best-in-class z capture range with consistent localization precision. Stackable to >10 µm using piezo stage.
	Probe the ultrastructure of molecular assemblies.	SMLM: Fast laser switching and / or Duolink for dual color acquisition.
		SMLM: High laser power densities across the visible spectrum; fine tuning of activation laser power (PALM).
	Put protein localization into structural context.	Lattice SIM / SMLM Correlative methods with ZEN Shuttle & Find and ZEN Connect.
	Overview and detailed imaging of a broad variety of specimen	SIM Apotome: Superfast imaging for large volumes in multiple colors with high axial resolution.

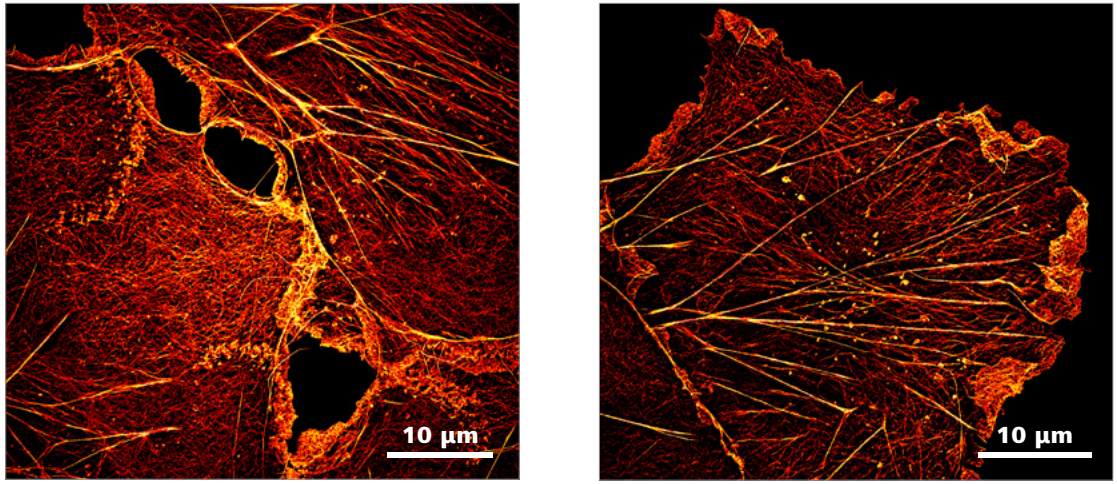
ZEISS Elyra 7 at Work

Lattice SIM² – Simply Image More

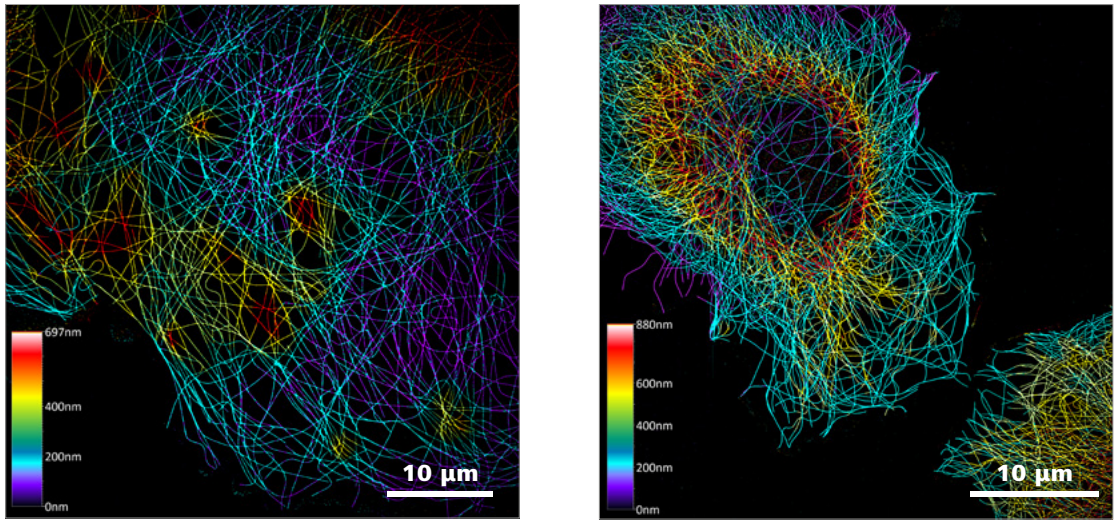
Study of the components of the cytoskeleton is a prominent research field in biology. Due to the fine structures of these components, for example the actin network or microtubular filaments, imaging far below 100 nm is often performed with super-resolution techniques.

Lattice SIM² now allows you to gain much more structural information from your samples compared to conventional SIM techniques. It not only operates with a resolution of down to 60 nm but also provides markedly improved sectioning quality in your images. This novel, robust image reconstruction method efficiently separates signal and background – all without the need for tailor-made staining protocols or expert knowledge of complex microscopy techniques.

You can take advantage of the easy-to-use Lattice SIM² technology to unveil complex structural information and simply see more.



The Lattice SIM² images of Cos-7 cells labeled with phalloidin Alexa 488 were acquired with a Plan-Apochromat 100×/1.57 oil objective. Maximum intensity projection of Z stack is shown.



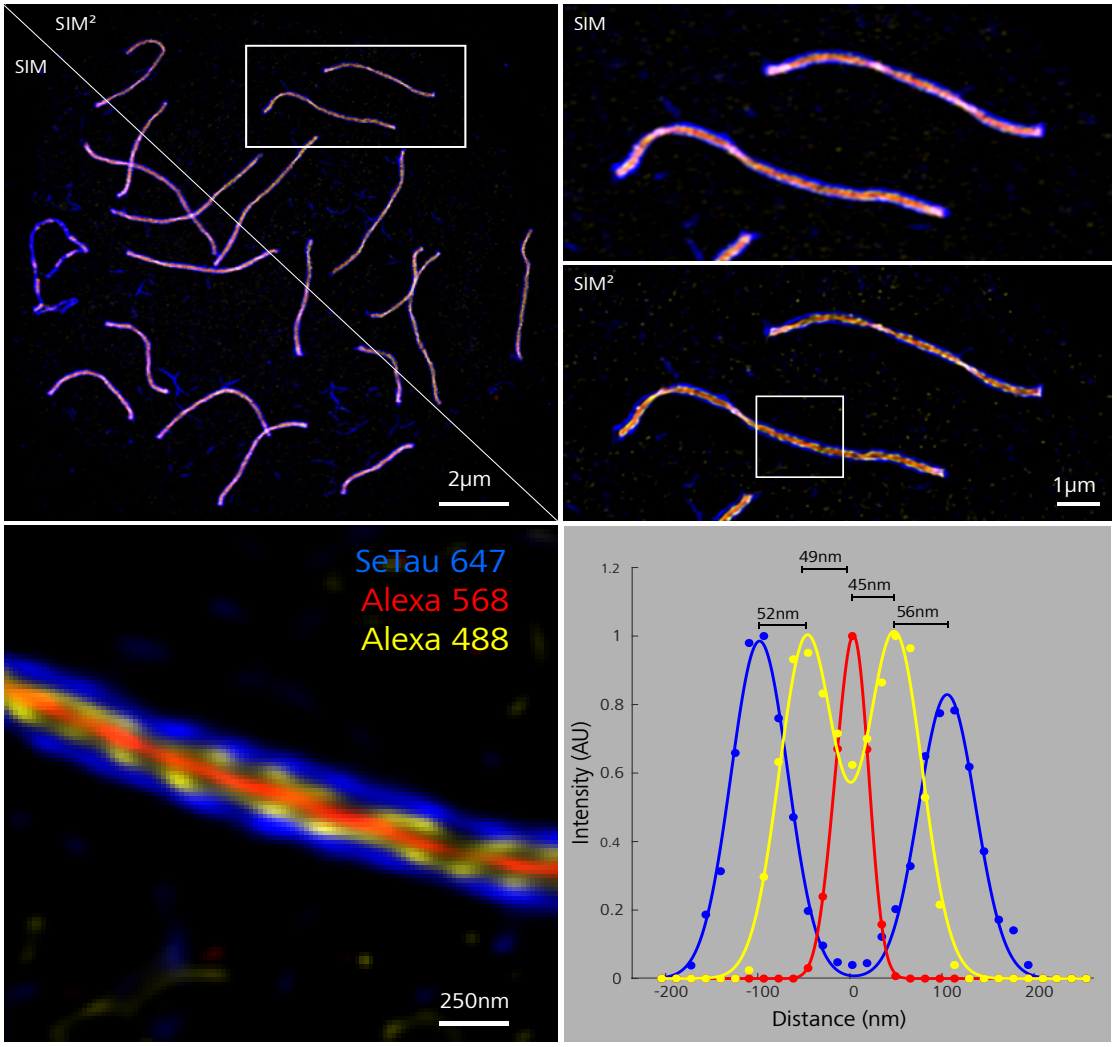
The Lattice SIM² images of Cos-7 cells labeled via immunofluorescence with anti-alpha-Tubulin Alexa 488 are shown as color-coded projection. Data were acquired with Plan-Apochromat 100×/1.57 oil (left) and Plan-Apochromat 63×/1.4 oil (right) objectives. The images demonstrate the excellent sectioning capabilities of SIM² image reconstruction algorithm.

ZEISS Elyra 7 at Work

Straightforward multi-color super-resolution imaging

Studying multiprotein complexes requires super-resolution imaging with multiple colors, which is not always easily achieved with conventional techniques. Lattice SIM² enables you to perform multi-color imaging at resolution down to 60 nm for conventionally stained samples.

The synaptonemal complex is a well-known structure in the nucleus of meiotic cells and consists of two lateral elements which are connected to a central element by transverse filaments. Due to its small size, three-color imaging of the synaptonemal complex has previously been possible only using complex methods like super resolution imaging of three-fold expanded samples. Lattice SIM² resolves the two strands of SYCP3 (lateral elements) as well as SYCP1-C (C-terminus of transverse filaments) without special sample treatment or staining for distances well below 100 nm. More importantly, the three-color image provides structural information about the distances between the proteins SYCP3 and SYCP1. Even within the SYCP1 protein, the different labeled N- and C-Terminus can be clearly separated with less than 50 nm resolution between the two labels.



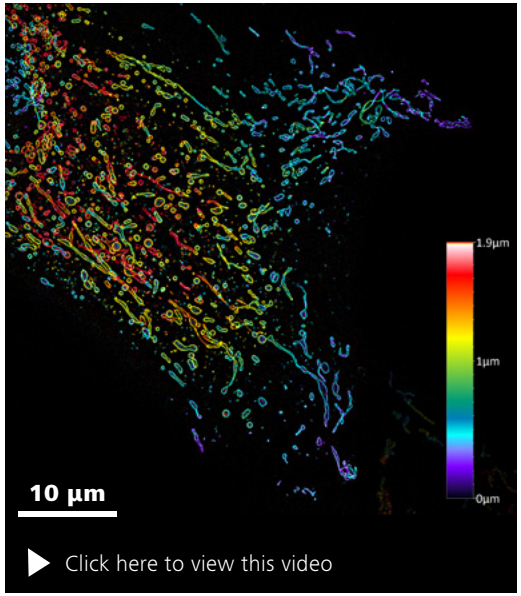
Architecture of threefold labeled synaptonemal complexes from mouse testis visualized via immunolabeling of SYCP3 with SeTau647, SYCP1-C with Alexa 488 and SYCP1-N with Alexa 568 and Lattice SIM² mode. Sample courtesy: Marie-Christin Spindler, AG Prof Ricardo Benavente, Biocenter of the University of Würzburg. Objective: Plan-Apochromat 63×/1.4 Oil

ZEISS Elyra 7 at Work

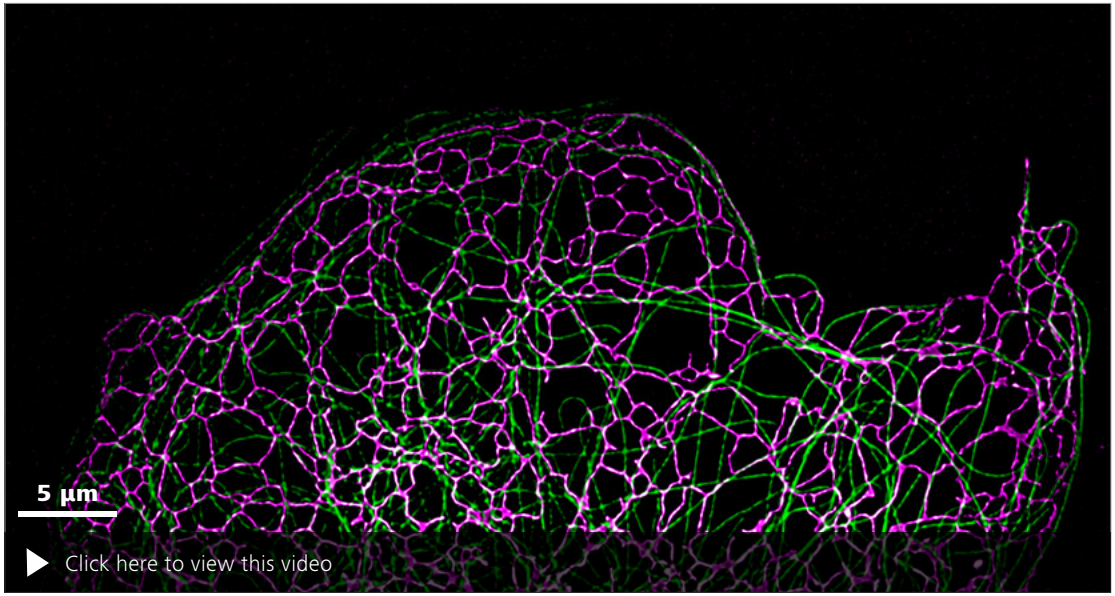
Observe life's finest details

Understanding biological processes is all about observing them in the living cell or organism – at low light dosage and high spatiotemporal resolution. Elyra 7 with Lattice SIM² is your super-resolution technique designed for imaging live specimens. Due to its unique lattice structural illumination, it combines high speed imaging with incredible light efficiency, low photon dosage and sensitivity.

You can observe cellular, subcellular, and even sub-organelle structures in living specimens in 2D and 3D over time. Whether you are interested in the dynamics of mitochondrial movement, fusion and fission or budding of the endoplasmic reticulum, Elyra 7 Lattice SIM² provides you with the necessary live cell compatibility at super-resolution.



U2OS cell expressing Tomm20-mEmerald. Image shows a color-coded projection of the Lattice SIM² volume data set. Objective: Plan-Apochromat 63×/1.4 Oil



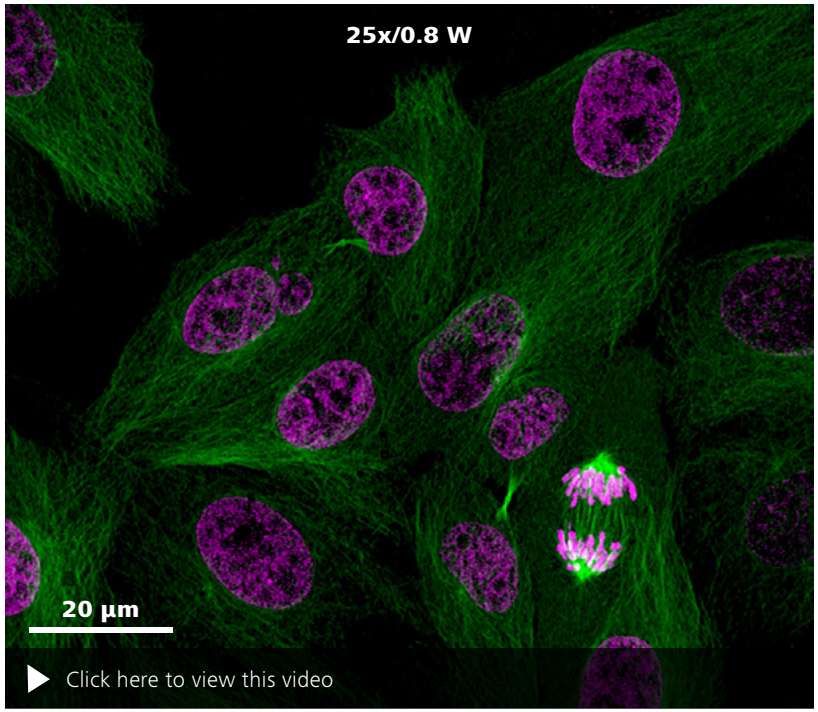
Simultaneous imaging of the endoplasmic reticulum (Calreticulin-tdTomato, magenta) and microtubules (EMTB-3xGFP, green) in a Cos-7 cell reveals highly dynamic interaction of these organelles. Objective: Plan-Apochromat 63×/1.4 Oil

ZEISS Elyra 7 at Work

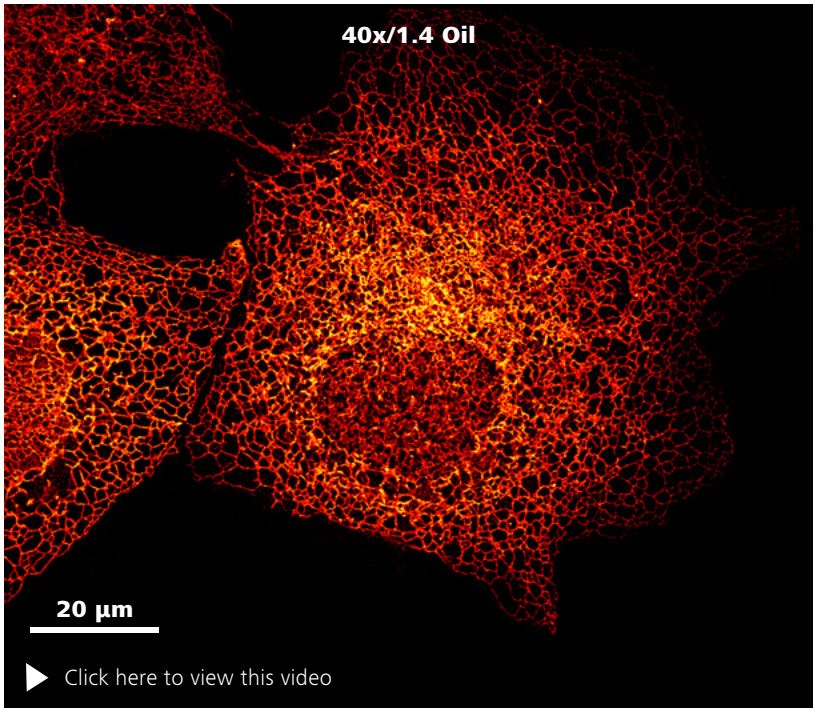
Excellent sectioning at incredible speed

SIM² Apotome is your flexible live cell imaging method for experiments that do not require the highest spatial resolution but rely instead on excellent sectioning quality. SIM² Apotome is superior to conventional confocal microscopy in terms of lateral and axial resolution as well as volume acquisition speed while it is also very gentle to your sample. Here, LLC PK1 cells expressing H2B-mCherry and α-Tubulin mEmerald-GFP were continuously observed with a 25×/0.8 water immersion objective over 35 min, while undergoing mitosis.

SIM² Apotome is compatible with objectives of different magnifications (10×, 20×, 25× and 40×). The high NA (1.4) 40× magnification images almost reach the resolution and sectioning capabilities of a conventional SIM microscope as demonstrated for Cos-7 cell expressing Calreticulin-tdTomato, while multiplying acquisition speed.



SIM² Apotome time lapse data of LLC PK1 cells expressing H2B-mCherry (magenta) and α-Tubulin mEmerald-GFP (green). Data shown as maximum intensity projection of 12 planes over 3.7 µm depth. Objective: LD LCI Plan-Apochromat 25× / 0.8 Imm Corr



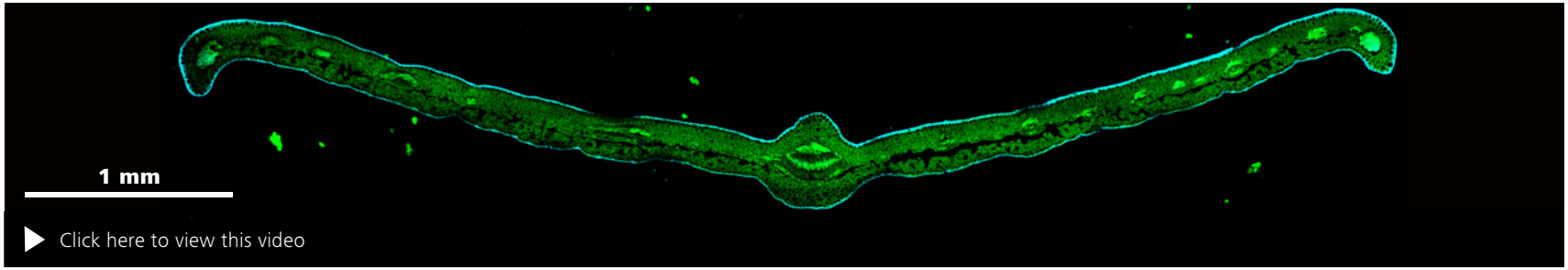
SIM² Apotome time lapse data of Cos-7 cells expressing the endoplasmic reticulum marker Calreticulin-tdTomato. Data shown as maximum intensity projection of 12 planes over 1.4 µm depth. Objective: Plan-Apochromat 40×/1.4 Oil

ZEISS Elyra 7 at Work

Get a quick overview –
at excellent image quality

The high-speed performance of SIM Apotome acquisition mode allows for fast tile scan imaging of very large areas at excellent sectioning quality. A mulberry section of 11.1 mm² × 11 µm size was imaged using Nyquist sampling in all three directions and in two colors in less than 2 minutes. Similar speeds also were achieved for a cross section of a leaf.

SIM² Apotome volume tile scan image of a thin mulberry section with an EC Plan-Neofluar 10×/0.3 air objective.
Data shown as maximum intensity projection over 11 µm depth. Sample: "Maulbeere" from TS-Optics Set Dauerpräparate Botanik 25St.

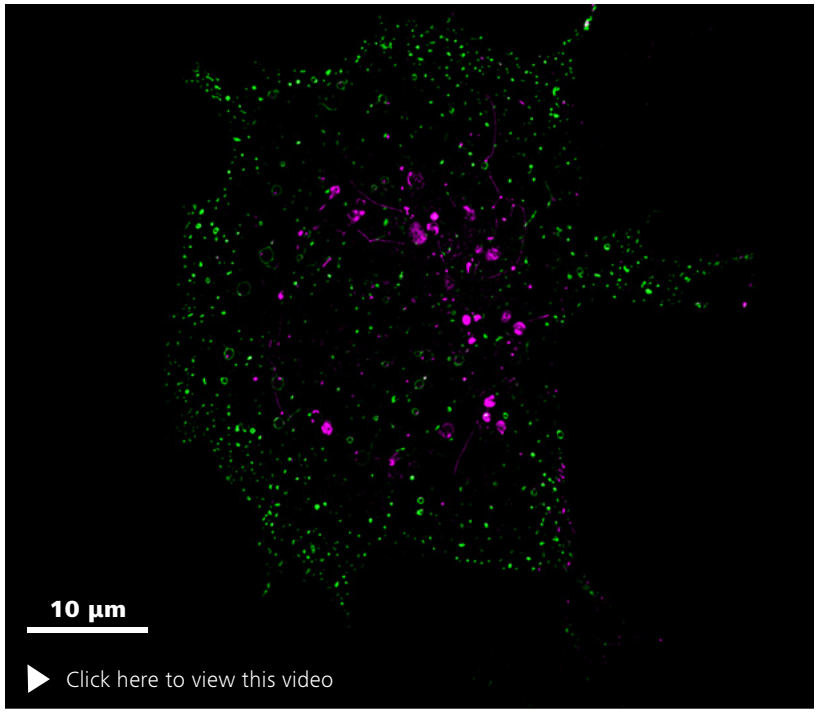


SIM² Apotome volume tile scan image of a leaf cross section, imaged with an EC Plan-Neofluar 10× / 0.3 objective. The image shows a maximum intensity projection of a Z stack.
Sample: "Leaf" from TS-Optics Set Dauerpräparate Botanik 25St.

ZEISS Elyra 7 at Work

Super-resolution imaging at up to 255 fps

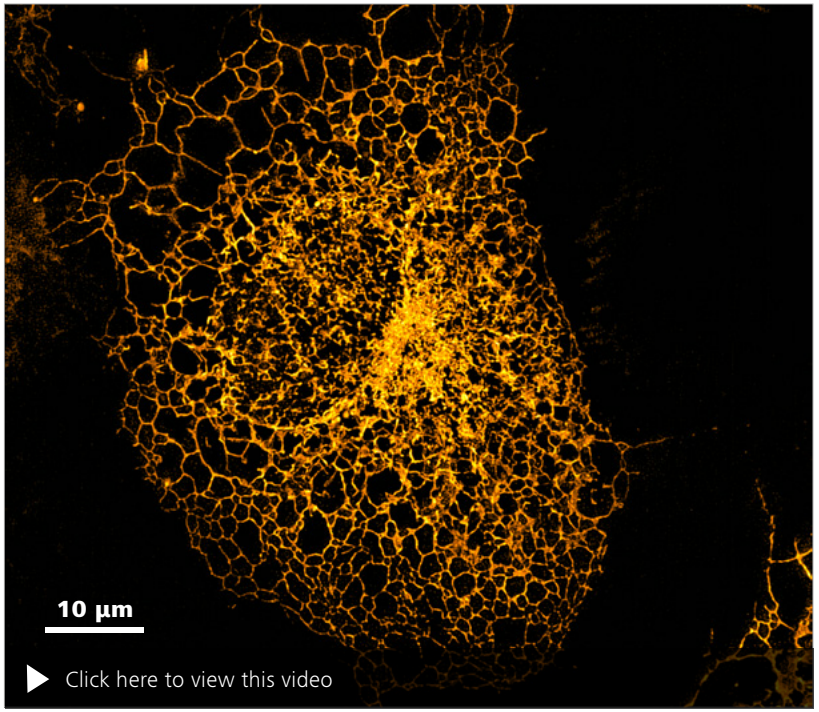
The diffusive and especially the ballistic movement of small vesicles in cells can be captured only when super-resolution and high-dynamic imaging are possible at the same time. With the Burst processing of 2D time lapse data, Elyra 7 is able to generate super-resolution images at 255 Hz in a large field of view and even acquire two colors simultaneously in both Lattice SIM and SIM Apotome acquisition modes.



U2OS cell expressing Rab5-mEmerald (green) and tdTomato tagged Golgi associated transport marker (magenta). Simultaneous dual-color acquisition with an exposure time of 1.5ms / phase for a FOV of 1024 × 1024 pixel (64 µm × 64 µm). Objective: Plan-Apochromat 63× / 1.4 Oil

Digital sectioning for 3D imaging three times faster

Elyra 7 Leap mode accelerates the volume imaging speed three times and at the same time decreases the light dosage on your sample. While still capturing all the finest details, the entire volume (18 planes) of the U2OS cell expressing Calreticulin-tdTomato was imaged at 38 volumes / min speed in Lattice SIM acquisition mode. For SIM Apotome acquisition mode, you can expect up to three times higher volume imaging speed.



U2OS cell expressing calreticulin-tdTomato to visualize the endoplasmic reticulum. The time series shows a maximum intensity projection of the volume data set. Objective: Plan-Apochromat 63× / 1.4 Oil

ZEISS Elyra 7 at Work

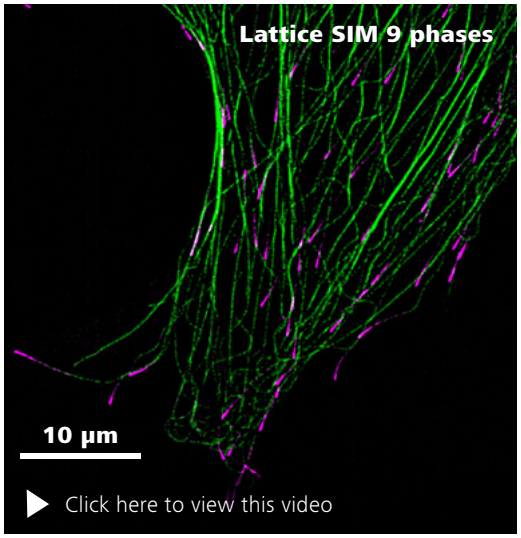
Define your specific needs for speed and resolution

The need for higher imaging speeds and decreased light dosage is almost unlimited. For SIM techniques, this translates mainly into a reduction of number of phase images required for the reconstruction of one final frame.

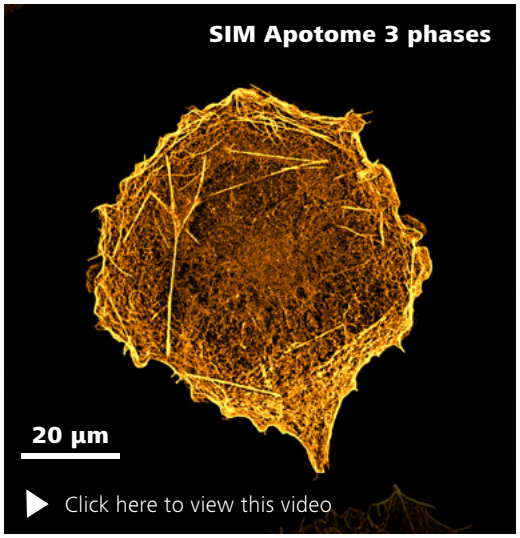
The robustness of Elyra 7 structured illumination patterns plus the image reconstruction software allow a significant reduction to the number of phase images required for both Lattice SIM and SIM Apotome acquisition modes, while decreasing the resolution only slightly.

Lattice SIM acquisition can be operated at 9 phase images per frame while 3 phase images per frame are sufficient for SIM Apotome, increasing the imaging speed by 44 % and 66 %, respectively. The increased imaging speed is also advantageous for fast screening of large samples areas.

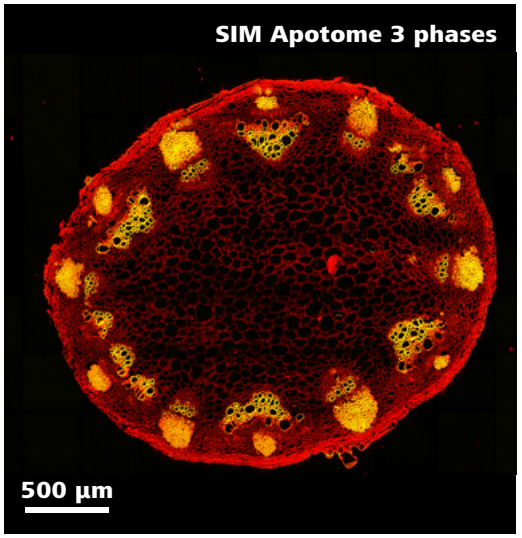
In combination with Leap mode, the reduced phase acquisition of Lattice SIM and SIM Apotome decreases the number of phase images per final frame. Thus, for Lattice SIM you need only three times more phase images than the resulting number of reconstructed full frames. More astonishingly, the SIM Apotome Leap mode is entirely lossless and provides the same number of phase images and processed frames.



Cos-7 cell expressing EMTB-3xGFP (green) and EB3-tdTomato (magenta) shows dynamic movement of microtubules. Imaged in Lattice SIM 9 phase mode. Objective: Plan-Apochromat 63×/1.4 Oil



Actin dynamics in a Cos-7 cell expressing LifeAct-tdTomato were imaged with the SIM Apotome 3D Leap mode over time. The image shows a maximum intensity projection of 30 planes over 3.4 µm depth. Objective: Plan-Apochromat 40×/1.4 Oil



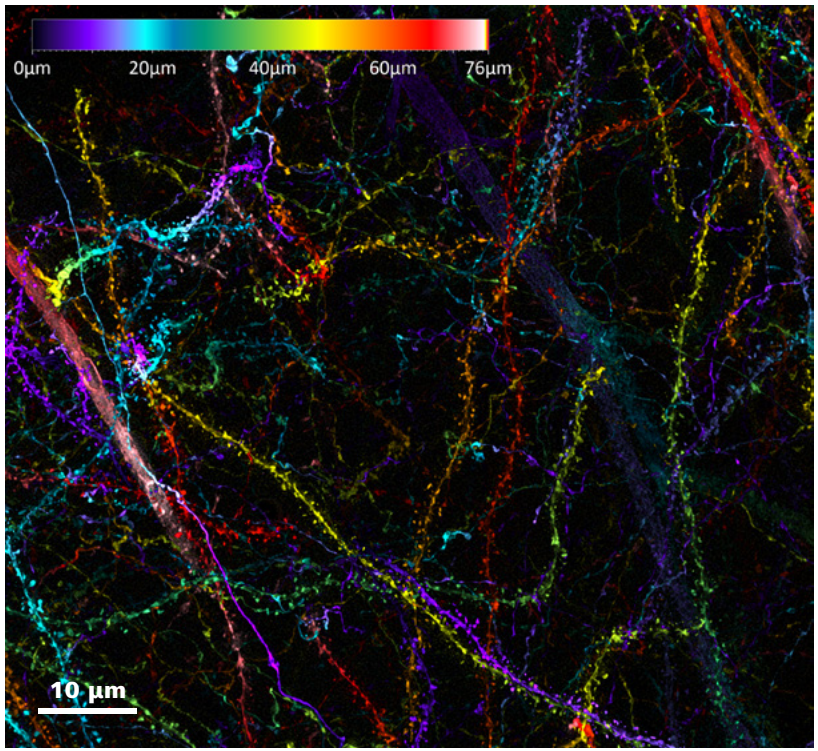
SIM Apotome volume tile scan image of a Helianthus section. Sample: "Helianthus" from TS-Optics Set Dauerpräparate Botanik 25St. Objective: EC Plan-Neofluar 10×/0.3

ZEISS Elyra 7 at Work

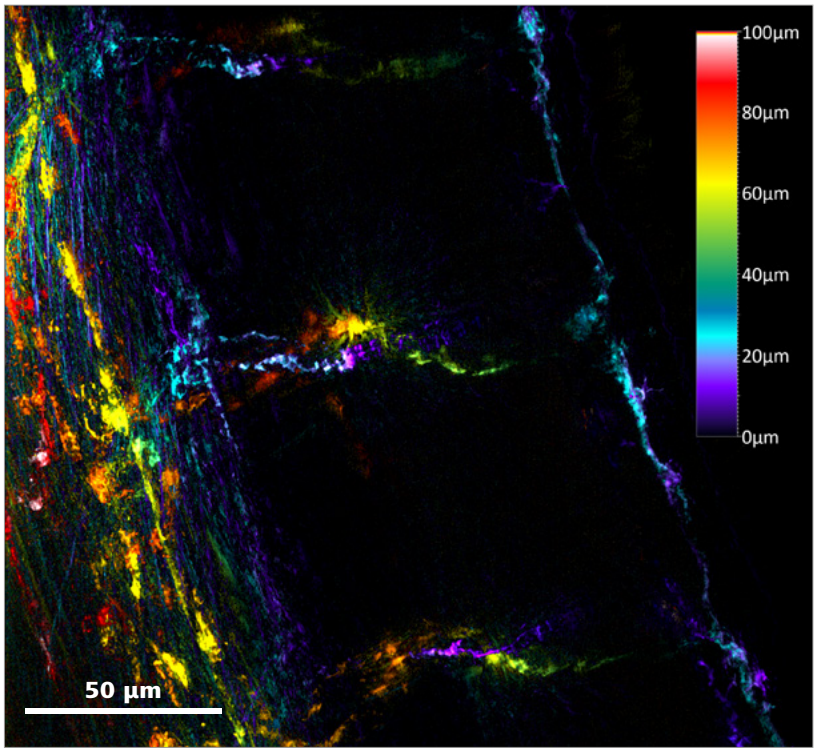
Resolve the details hiding in the depth

Despite being a structured illumination-based microscope, Elyra 7 Lattice SIM² as well as SIM² Apotome also provide you with super-resolution and high-quality sectioning in thick or scattering samples.

The combination of robust illumination patterns and excellent image reconstruction technology enabled us to image throughout an entire murine brain section of ~80 µm thickness expressing the neuronal marker Thy1-eGFP.



Murine brain expressing the neuronal marker Thy1-eGFP was imaged in Lattice SIM mode over a Z stack range of 75 µm. The image shows the color-coded projection of the volume data. Objective: Plan-Apochromat 63×/1.4 Oil. Sample courtesy of Herms Lab (MCN, University of Munich, Germany)

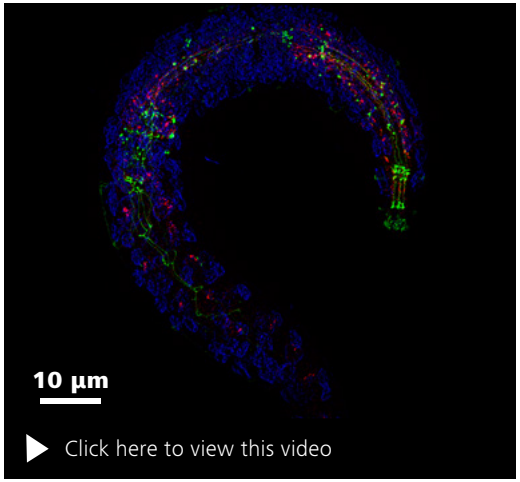


Zebrafish embryo expressing a vascular marker fli1-EGFP was imaged in SIM Apotome mode over a Z stack range of 100 µm. The SIM² processed image shows the color-coded projection of the volume data. Objective: LD LCI Plan-Apochromat 25×/0.8 Imm Corr. Sample courtesy of Haass Lab (MCN, University of Munich, Germany)

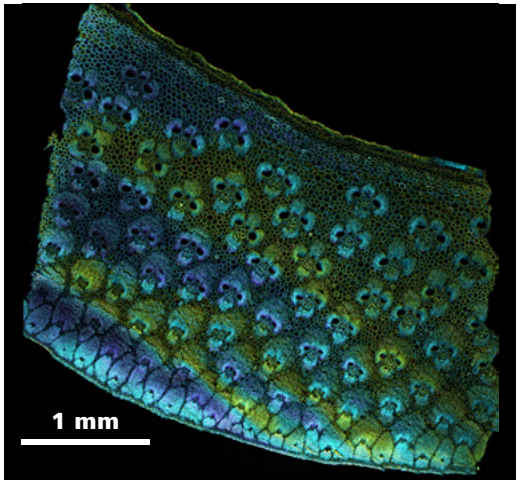
ZEISS Elyra 7 at Work

Discover the diversity of life

Elyra 7 is your flexible widefield system for a large variety of samples. You can investigate living or fixed, small or large, thin or thick specimens using Elyra 7 Lattice SIM², SIM² Apotome or SMLM modes. Whether you study vesicle dynamics in cells or yeast or you want to unravel the architecture of plants, *C. elegans*, zebrafish, *D. melanogaster* or bacteria, with Elyra 7 you will experience easily accessible super-resolution imaging for your favorite model organism and many other specimens – today and in the future.

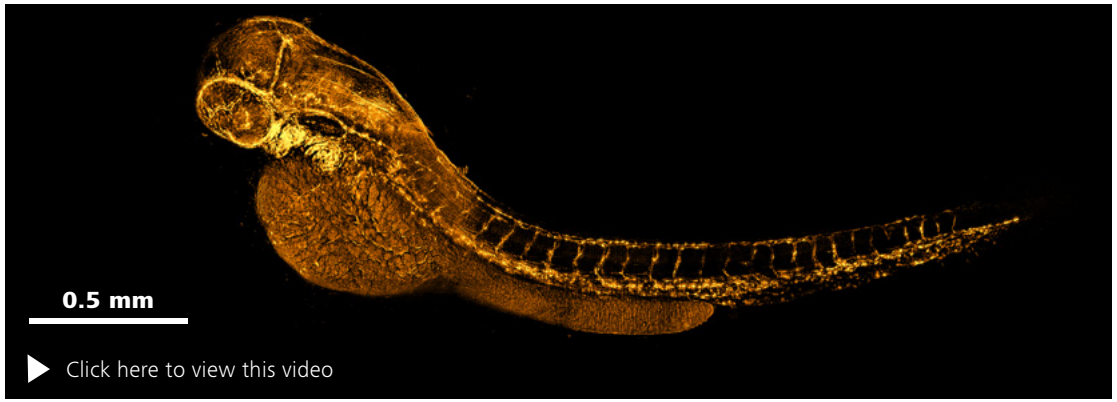


Lattice SIM² 3D image of a C. elegans *larvae.*
Image shows a maximum intensity projection.
Sample courtesy of Mango Lab (University of Basel, Switzerland)



SIM² Apotome: An entire 3D cross section (~13 mm²) of bamboo was imaged. Sample: "Bambus" from TS-Optics Set Dauerpräparate Botanik 25St.

Lattice SIM² time lapse images of living yeast expressing GFP-coupled membrane marker and mCherry-coupled Golgi associated protein. Sample courtesy of C. MacDonald, G. Calder & P. O'Toole (Department of Biology & Bioscience Technology Facility, University of York, UK)

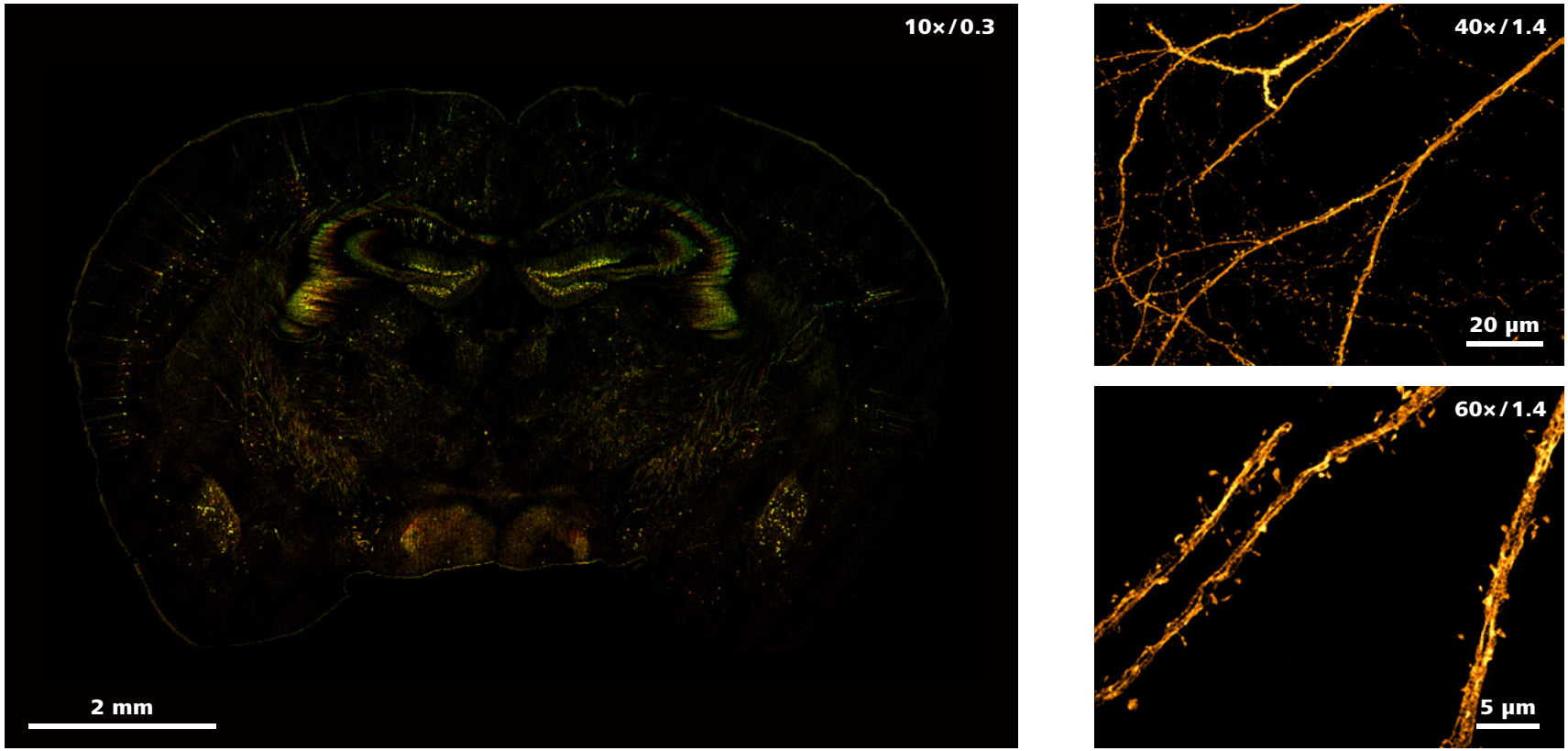


SIM² Apotome: Zebrafish embryo expressing a vascular marker fli1-EGFP was imaged in 3D.
The figure shows the maximum intensity projection of the tile scan Z stack data set. Objective: Plan-Neofluar 10×/0.3.
Sample courtesy of Haass Lab (MCN, University of Munich, Germany)

ZEISS Elyra 7 at Work

A journey through different scales – from overview to detailed imaging

Biological samples often contain completely different types of information at different length scales. Being able to collect low to high resolution data in the same sample not only makes you more productive but also interconnects the findings and puts them in context to give you the whole picture.



Lattice SIM² and SIM² Apotome images of a murine brain expressing the neuronal marker Thy1-eGFP. The images show the color-coded or maximum intensity projections of the volume data. Objectives: Plan-Neofluar 10×/0.3, Plan-Apochromat 40×/1.4 Oil and Plan-Apochromat 63×/1.4 Oil. Sample courtesy of Herms Lab (MCN, University of Munich, Germany)

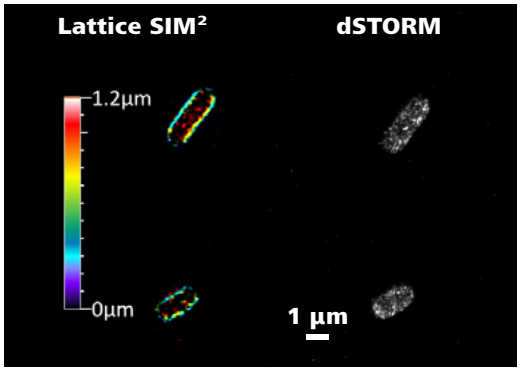
ZEISS Elyra 7 at Work

Correlative microscopy within the same system

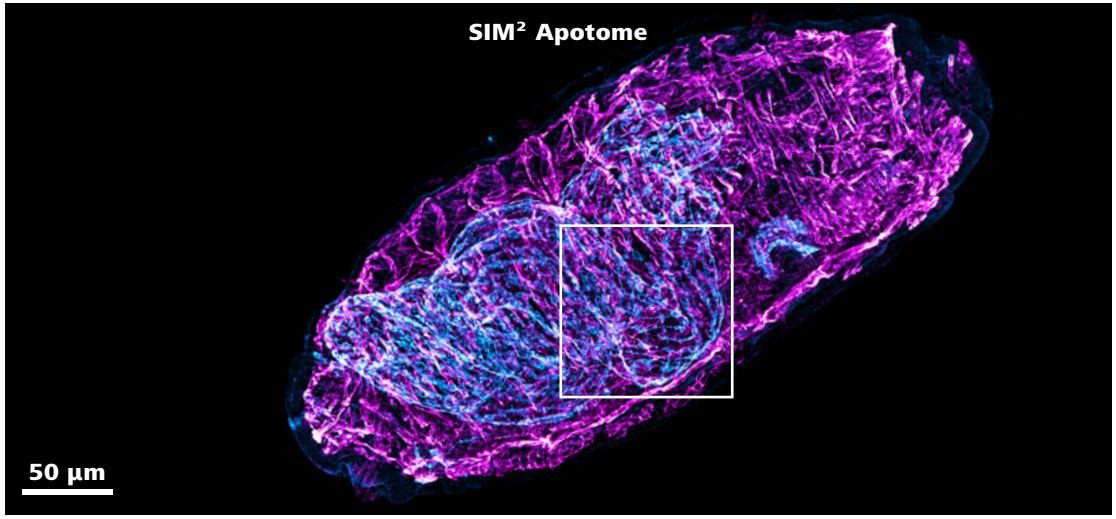
Correlative microscopy, where the same area of the sample is imaged using different techniques, has become an important tool for biological research. Imaging with Elyra 7 can be combined seamlessly with LSM 980 Airyscan or ZEISS electron microscopy solutions. Nevertheless, Elyra 7 itself contains three different imaging modalities – SIM Apotome, Lattice SIM and SMLM – providing the possibility to combine them when needed for sample scales varying by orders of magnitude.

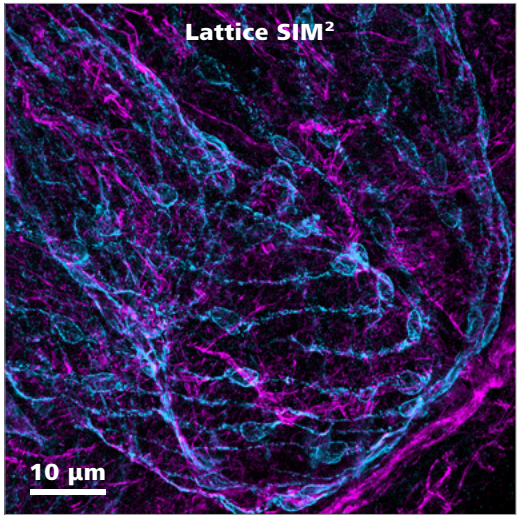
Here, a detailed SIM² Apotome overview volume image of a drosophila larvae was combined with the super-resolution Lattice SIM² volume image of a region of interest, putting the super-resolved area into full context.

Another advantageous combination is the pre-imaging of SMLM samples with Lattice SIM² to easily identify interesting sample areas at resolutions of 60 – 100 nm, then perform the more time-consuming localization microscopy on suitable cells.



Lattice SIM² and dSTORM images of bacteria stained with a membrane marker coupled to Alexa Fluor 647. Sample courtesy of J. Nabarro, C. Baumann, G. Calder & P. O'Toole (Department of Biology & Bioscience Technology Facility, University of York, UK)





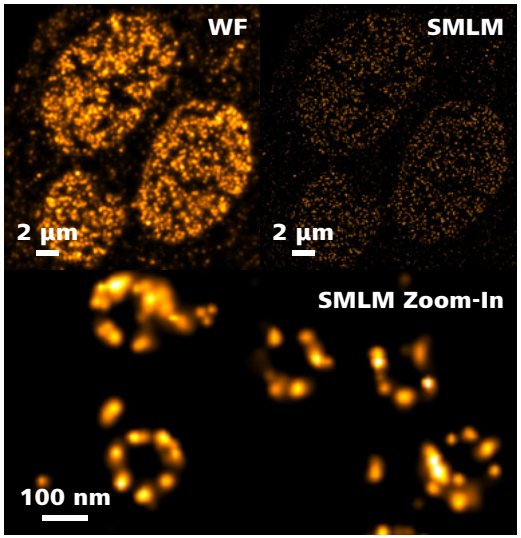
SIM² Apotome and Lattice SIM² images of D. melanogaster larva stained with HLH-54F-GFP (cyan) and Anti-Cut-Cy3 (magenta). Images show maximum intensity projections of 3D data. Sample courtesy of R. Palmer and G. Wolfstetter (University of Gothenburg)

ZEISS Elyra 7 at Work

Single-molecule localization microscopy (SMLM)
SMLM encompasses techniques such as PALM, dSTORM, and PAINT. With high power lasers across the visible spectrum and dual camera detection, Elyra 7 allows researchers to gain access to a broad range of dyes, markers and fluorophores in almost any possible combination.

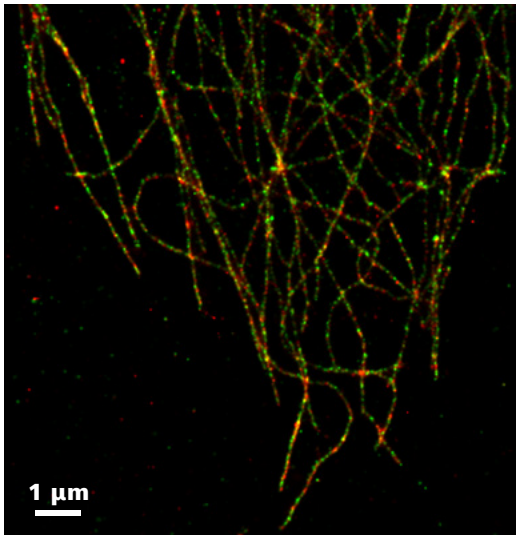
Elyra 7 enables precise quantification over a large field of view and an unprecedented Z-capture range. You now can acquire 3D data from a whole cell with molecular precision.

Resolve molecular structures
SMLM allows you to map precise locations of individual proteins.



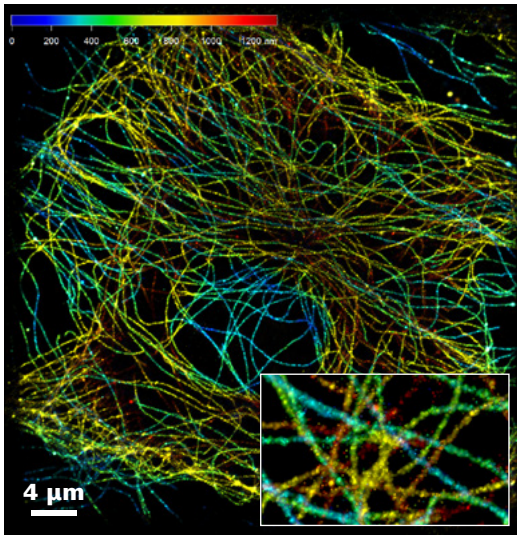
SMLM: Eightfold symmetry of the nuclear pore complex in A6 cells. Gp210 was labeled with Alexa Fluor 647. Widefield image (top left), SMLM image (top right) and zoomed in region (bottom).

Determine the relationships between molecules
Detect two channels with molecular precision.



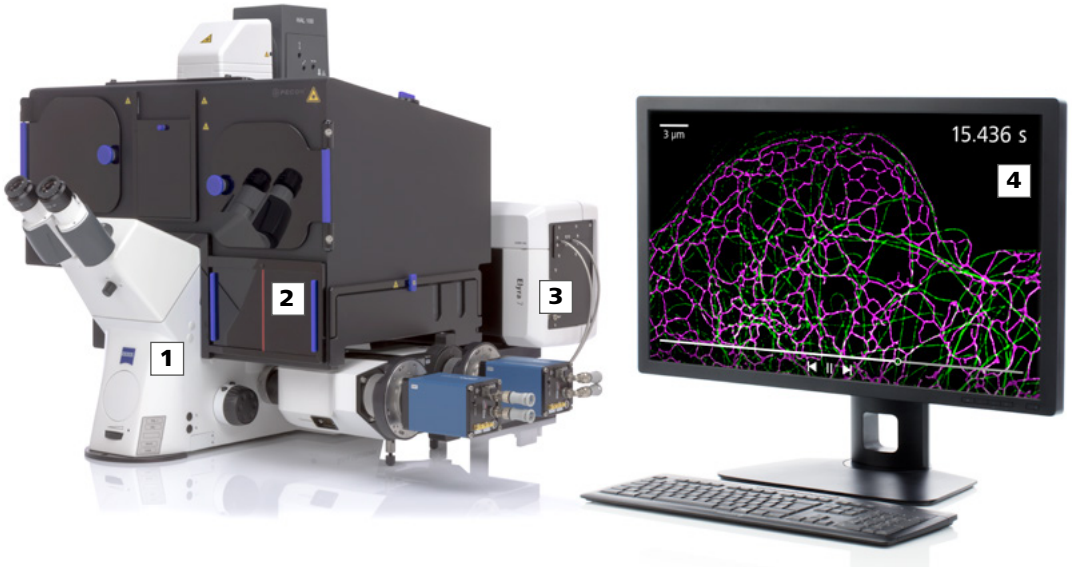
SMLM: Alpha tubulin was labelled with Alexa 555 and beta tubulin with Alexa 488. The two channels were acquired simultaneously. The epitopes are either occupied by a green or red fluorophore – shown by the mutual exclusion between the green and the red signals.

Capture information in three dimensions
Untangle molecular relationships in Z with confidence.



SMLM: With Elyra 7 you can image a Z-depth of 1.4 µm in a single acquisition. 3D SMLM image of Alexa 647 α-tubulin color-coded for depth.
Sample courtesy of Michael W. Davidson, Florida State University, USA.

Your Flexible Choice of Components



1 Microscope

- Axio Observer 7 (inverse stand)
- Incubator XL dark and top stage incubation
  Motorized Piezo XY scanning stage
- Z-Piezo stage insert
- 2 camera ports or one camera port with Duolink

2 Objectives

- C-Apochromat 63×/1.2 Water (DIC)
- Plan-Apochromat 63×/1.4 Oil (DIC)
- alpha Plan-Apochromat 100×/1.46 Oil (DIC)
- alpha Plan-Apochromat 100×/1.57 Oil HI Corr (DIC)
- alpha Plan-Apochromat 63×/1.46 Oil
- C-Apochromat 40×/1.2 W
- Plan-Apochromat 40×/1.4 Oil (DIC)
- LD LCI Plan-Apochromat 25×/0.8 Imm Corr
- Plan-Apochromat 20×/0.8 Air
- EC Plan-Neofluar 10×/0.3 Air

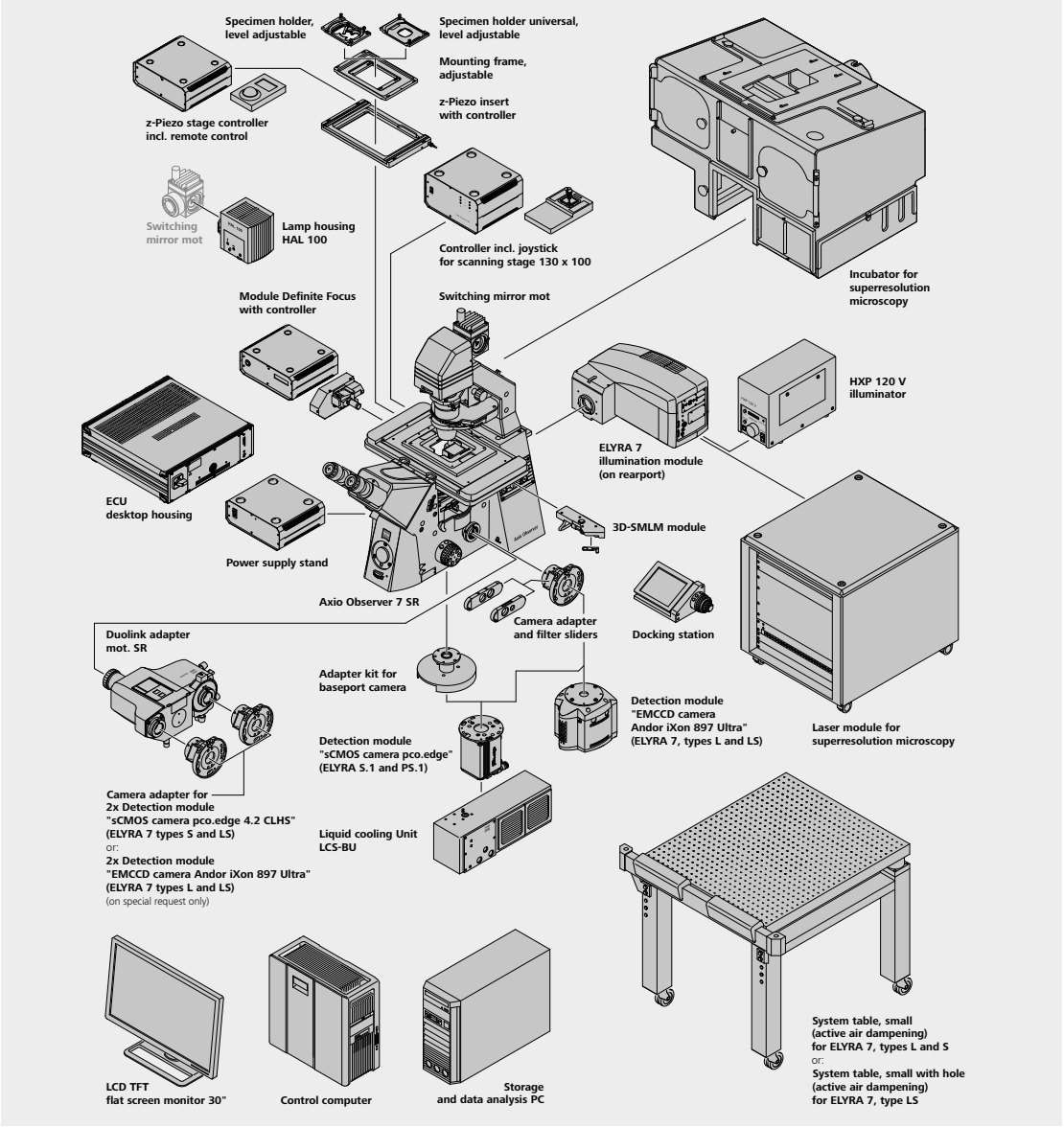
3 ZEISS Elyra 7 Illumination and Detection

- Fiber coupled solid state or diode pumped
  solid state lasers
- Available lines:
  405 nm diode (50 mW),
  488 nm OPSL (100 or 500 mW),
  561 nm OPSL (100 or 500 mW),
  642 nm diode (150 or 500 mW)
- Lasers shared between Lattice SIM and SMLM
- Andor iXon 897 EM-CCD camera (SMLM)
- PCO edge sCMOS camera
  (Lattice SIM, SMLM, SIM Apotome mode)

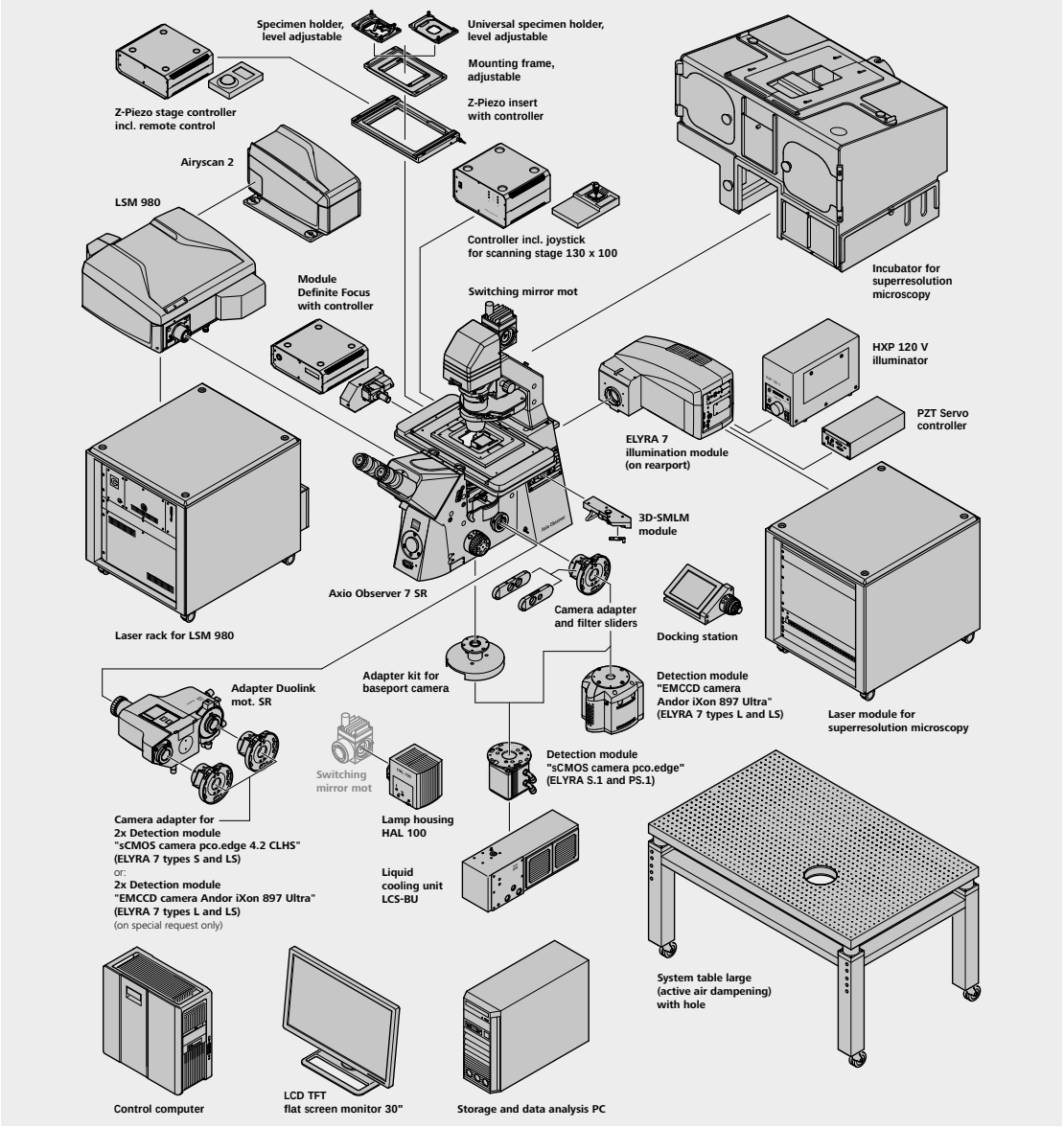
4 Software

- ZEN (black edition)
- Lattice SIM² / SIM² Apotome module
- SMLM (PALM / dSTORM) module
- 3D-PALM module

System Overview



System Overview



Technical Specifications

Microscope	
Stand	Axio Observer 7, motorized inverted microscope for superresolution microscopy
Z-drive	DC servomotor, opto-electronically coded; smallest Z step 25 nm
XY Piezo Scanning Stage	motorized; range 130 mm × 100 mm; max sped 100 mm/s; resolution 0.2 µm; reproducibility: ± 1 µm; absolute accuracy ± 5 µm; suitable for mounting frames K 160 × 110 mm and Z-Piezo Stage insert
Z-Piezo Stage insert	for XY scanning stage, max travel range 100 µm; smallest Z step size 5 nm, sample holders available for standard 3''×1'' slides LabTek chambers, multiwell plates and 36 mm glass-bottom dishes; level-adjustable and universal stage insert available for standard slides, glass-bottom dishes and LabTekTM chambers.

Optical Filters for Lattice SIM and SMLM	
Filter sets reflector turret	Four exchangeable filter sets available for multi-channel Lattice SIM and SMLM; each filter set with four precisely mounted ACR-coded(1) filter modules for superresolution microscopy on a motorized six-position turret; two positions in each turret compatible with standard Push & Click filter modules, e.g. for visual sample observation.
Dual filter sets for Duolink optimized for dual color and double dual color applications	Filter sets are optimized for dual camera applications, maximum sensitivity, minimal cross-talk and reduced autofluorescence.
Filter slider	Manual filter slider with two positions (for emission filters or a Bertrand lens); fits into camera adapter of the microscope's side port; emission filters exchangeable for customizing detection conditions.

Lasers	
Laser module for Elyra 7	Laser coupling with polarization-maintaining single mode fiber (no adjustment of laser coupling by users required).
Laser Lines	405 nm (50 mW), 488 nm (100 mW or 500 mW), 561 nm (100 mW or 500 mW), 642 nm (150 mW or 500 mW); 405 laser can be attenuated by up to 100000 fold (used for activation and back-pumping); high power lasers (500 mW) can be 10 fold attenuated (488, 561, 642)

Cameras	
Camera for SMLM	Andor iXon 897 back-thinned EMCCD camera; pixels: 512 × 512; pixel size: 16 µm × 16 µm; QE: 90 % (camera specifications by Andor)
Camera for Lattice SIM and SMLM	pco.edge 4.2 sCMOS camera; effective pixels: 1280 × 1280; pixel size 6.5 µm × 6.5 µm; QE: 82 %; dynamic range 15 bit (camera specifications by PCO)
	Liquid cooling system for EMCCD and sCMOS cameras

Technical Specifications

Elyra 7 for SMLM	
Illumination module	Fully motorized Epifluorescence (EPI), high inclined and laminated optical sheet (HILO) and total internal reflection illumination (TIRF); simultaneous TIRF illumination with VIS and 405 nm laser lines; individual triggering of lasers for synchronizing dye activation and illumination to camera read-out and transfer times; motorized TIRF angle adjustment; motorized TIRF field adjustment with three field size options
3D-PALM module	Double phase ramp in pupil plane of back aperture of objective providing for phase ramp imaging localization microscopy (PRILM); z capture range typically 1.4 µm; multi-plane acquisition possible to extend z range
Cameras	EMCCD camera (mounted to right side port of microscope); or up to two pco.edge sCMOS cameras (mounted to the right side port of microscope) 100× objectives to be used for EMCCD camera with 1.6× tube lens; 63× objectives to be used for sCMOS camera with 1× tube lens
Objective lenses (SMLM)	alpha "Plan-Apochromat" 100× / 1.46 Oil DIC, alpha "Plan-Apochromat" 100× / 1.57 Oil-HI DIC Corr (2D-PALM), alpha "Plan-Apochromat" 63× / 1.46 Oil, "Plan-Apochromat" 63× / 1.4 Oil DIC, C-Apochromat 63× / 1.2 W Corr DIC (3D-PALM) ACR[1] coding (optional; Objectives with NA > = 1.46 suitable for TIRF and HILO illumination)
Imaging modes	Widefield (WF) mode (sample illumination with arc lamp), Laser WF mode (sample illumination with laser), SMLM mode for single-molecule localization microscopy
Field of view (SMLM)	Maximal field of view 51.1 × 51.1 µm² (with alpha Plan-Apochromat 100× / 1.46 Oil DIC, 1.6× tube lens, full chip recording); 127.6 × 127.6 µm² (with Plan-Apochromat 63× / 1.4 OIL DIC, 1.0× tube lens, full chip recording); HP field 2× smaller, uHP field 2 × √2 smaller than TIRF field
Localization precision (SMLM)	Typically 20 nm – 30 nm lateral, 50 nm – 80 nm axial, given sufficient signal-to-noise
Multi-color imaging (SMLM)	Detection of up to two different fluorescent labels (simultaneous with Duolink or quasi simultaneously by fast sequential laser switching)
Acquisition speed (SMLM)	EMCCD: TIRF (SMLM) and widefield mode: up to 30 frames per second (full frame mode, 512 × 512 pixels); >100 frames per second in sub-array mode; sCMOS (dSTORM) and widefield mode > 200 frames per second (512 × 512 pixels)
Data recording and analysis (SMLM)	Full software control of SMLM imaging; software holding focus based on fiducial markers; Definite Focus z-drift control
	Online SMLM processing for simultaneous data acquisition and analysis; manual editing of parameter settings for optimal results in SMLM with different fluorophores; feature-rich rendering of SMLM localization tables; export and import of localization tables for custom filtering; correction algorithms for lateral and axial drift; chromatic aberration correction (based on fiducial markers or prominent structures)
	Multi-emitter fitting algorithms allow to analyze overlapping signals with high precision. Up to 10 times higher labeling densities are possible speeding up acquisitions by the same factor.

Technical Specifications

Elyra 7 for Lattice SIM and SIM Apotome mode	
Illumination module	Fully motorized Lattice SIM imaging; five different grating frequencies for Lattice SIM for optimal matching of illumination pattern to laser wavelength and objective lens; motorized exchange of gratings in multi-color Lattice SIM; fast piezo actuated phase stepping of gratings.
Camera	Up to two sCMOS cameras mounted on right side port
Imaging Modes	Widefield modes for illumination with HXP 120 and lasers, Lattice SIM using two dimensional grid SIM mode (two- and three-dimensional Lattice SIM), SIM Apotome mode using one dimensional grid for z-sectioning
Objective lenses (Lattice SIM)	Plan-Apochromat 63× / 1.40 Oil DIC, C-Apochromat 63× / 1.20 W Corr, alpha "Plan-Apochromat" 63× / 1.46 Oil, ACR[1] coding (optional), alpha "Plan-Apochromat" 100× / 1.57 Oil-HI DIC Corr
Objective lenses (SIM Apotome mode)	Plan-Apochromat 40× / 1.4 Oil; C-Apochromat 40× / 1.2 W; EC Plan-Neofluar 10× / 0.3 Air; Plan-Apochromat 20× / 0.8 Air; LD LCI Plan-Apochromat 25× / 0.8 Imm Corr DIC
Resolution (Lattice SIM)	Lateral resolution (XY): 120 nm, axial resolution (Z): 300 nm (typical experimental FWHM values with objective lens Plan-Apochromat 63× / 1.40 Oil DIC, subresolution beads of 40 nm diameter and excitation at 488 nm)
Resolution (Lattice SIM²)	Lateral resolution (XY): down to 60 nm, axial resolution (Z): down to 200 nm (typical experimental FWHM values with objective lens Plan-Apochromat 63× / 1.40 Oil DIC, subresolution beads of 40 nm diameter and excitation at 488 nm; Resolution is sample and SNR dependent.)
Resolution (SIM² Apotome) (typical experimental FWHM values with subresolution beads of 40 nm diameter and excitation at 488 nm)	Lateral resolution (XY) of 140 nm, axial resolution (Z) of 275 nm for 40×; lateral resolution (XY) of 265 nm, axial resolution (Z) of 485 nm for 25×; lateral resolution (XY) of 285 nm, axial resolution (Z) of 550 nm for 20×; lateral resolution (XY) of 710 nm, axial resolution (Z) of 1300 nm for 10×
Multi-color (Lattice SIM and SIM Apotome mode)	Detection of up to four different fluorescent labels (sequential detection) and simultaneous dual color detection with DuoLink
Max. Field of view (Lattice SIM)	81.25 × 81.25 µm (processed: 78.32 × 78.32 µm), full-frame recording (1280 × 1280 effective px) with Plan-Apochromat 63× / 1.40 Oil DIC
Max. Field of view (SIM Apotome mode)	126 × 126 µm², full frame recording (1280 × 1280 effective px) with Plan-Apochromat 40× / 1.40 Oil 202 × 202 µm², full frame recording with LD LCI Plan-Apochromat 25× / 0.8 Imm Corr DIC; 252 × 252 µm², full frame recording with Plan-Apochromat 20× / 0.8 Air; 504 × 504 µm², full frame recording with EC Plan-Neofluar 10× / 0.3 Air
Acquisition speed (Lattice SIM)	17 SIM image frames per second at 512 × 512 px resolution and 1 ms exposure time (15 phase images per one SIM image) 19 SIM image frames per second at 512 × 512 px resolution and 1 ms exposure time (13 phase images per one SIM image) 28 SIM image frames per second at 512 × 512 px resolution and 1 ms exposure time (9 phase images per one SIM image)
Acquisition speed (SIM Apotome mode)	51 sectioned frames per second at 512 × 512 px resolution and 1 ms exposure time (camera limited) (5 phase images per one sectioned image); 85 sectioned frames per second at 512 × 512 px resolution and 1 ms exposure time (camera limited) (3 phase images per one sectioned image);
Leap mode and Burst mode	Leap and Burst modes are combinable with both the Lattice SIM and SIM Apotome. Leap mode increases the frame rate by a factor of 3 for 3D image acquisition. Max. 255 image frames per second at 512 × 512 px resolution and 1 ms exposure time are available for 2D data after Burst processing.
Data recording and analysis (Lattice SIM and SIM Apotome mode)	Full software control of Lattice SIM imaging; Multi-tracking (sequential multi-channel data acquisition with freely configurable change of gratings (Lattice SIM), or one common grating (SIM Apotome mode), filters and excitation lasers between tracks); Simultaneous dual color imaging with one grating; Lattice SIM and SIM Apotome mode imaging in user-defined sub-array regions (ROI imaging); Leap mode for 3 times faster imaging with excellent sectioning; Extension of imaged area possible with tile scanning and stitching. Burst mode processing for 2D time series data sets for Lattice SIM and Aptotome mode to increase effective frame rates by a factor of 15 and 5, respectively.

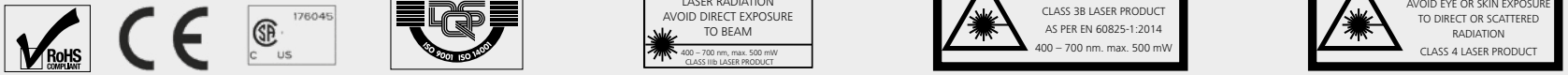
[1] ACR (Automatic Component Recognition); Elyra 7 systems and ZEN imaging software automatically recognize ACR-coded components.

Technical Specifications

Elyra 7 for combined Lattice SIM and SMLM)	
System information	All imaging modes combined in one system
Illumination module	Sample illumination in all widefield and superresolution modes by a single, highly integrated illumination module (with same set of lasers and a single Elyra laser module).
Cameras	Cameras for SMLM: Andor iXon 897 back-thinned EMCCD camera mounted to right side port of microscope. Camera for Lattice SIM: pco.egde sCMOS camera mounted to base port of microscope or Camera for combined SMLM and Lattice SIM: up to two pco.edge cameras mounted to the right side port of the microscope.

Software	
Standard	ZEN imaging software (64-bit); operating system: Microsoft Windows 10
	Full software control of image data recording in all imaging modes (including widefield, superresolution); Software-controlled switching between imaging modes. Full software control of data recording (multi-channel imaging, time series, z-stack) Saving and restoring of user-specific configurations for data recording.
Optional packages	ZEN 3D XL; in ZEN Blue ZEN StitchArt plus (extension of field of view by tile scanning and subsequent stitching of tiles with 2D and 3D data); ZEN Connect; ZEN Shuttle & Find

Accessories	
Definite Focus	Holding focus to compensate axial drift, typical z-position accuracy with an Elyra system: 30 nm. Specified limits: 100 nm for 63× objectives; 90 nm for 100× objectives.
Incubation	Large chamber incubation with Incubator XL dark S1, also prevents exposure to ambient light
	Stage-top incubation possible with z-piezo stage insert
Duolink for attachment of two cameras of the same type	Allows attachment of two cameras of the same type to the microscope.
Storage PC with 32 TByte storage capacity	Direct streaming of data and parallel processing while streaming of data possible



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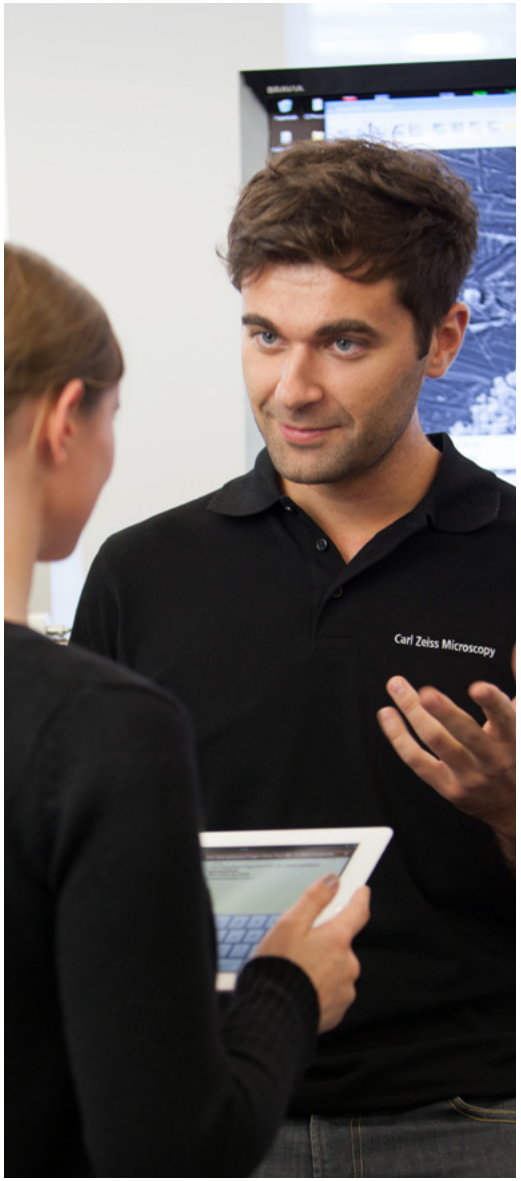

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