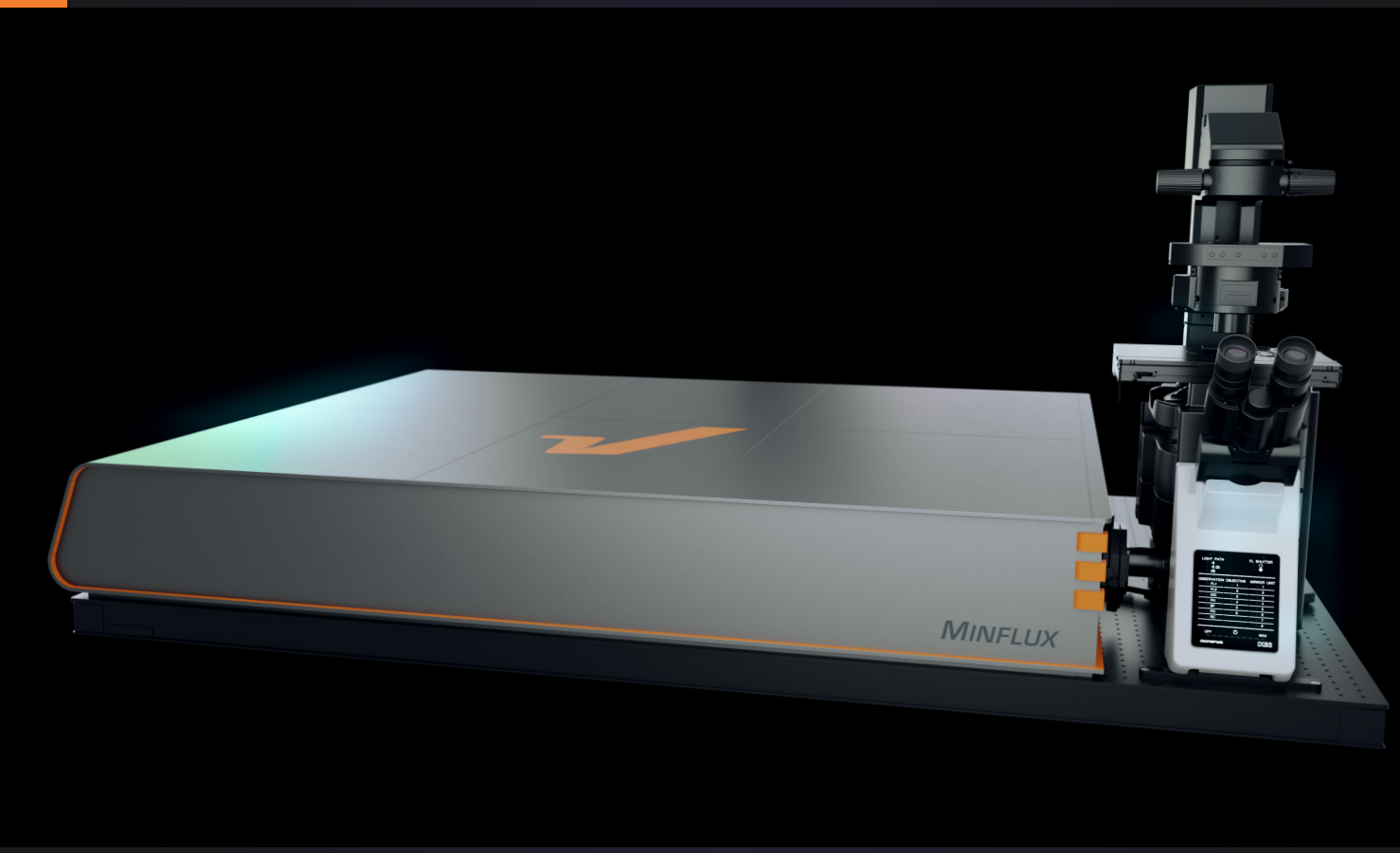
MINFLUX

The world‘s most powerful nanoscope



1-3 nm super-resolution

10 kHz molecular tracking

at your fingertips

abberior INSTRUMENTS

MINFLUX molecular tracking
100 times *faster*
than a camera

MINFLUX (minimal fluorescence flux) is the fastest way to localize fluorescent molecules. With its revolutionary MINFLUX nanoscope, Abberior Instruments is raising the bar for molecular nanoscale tracking with world-record temporal **resolution of 100 µs**, opening new doors for life-scientists across all disciplines.

SPEED

10 kHz tracking frequency

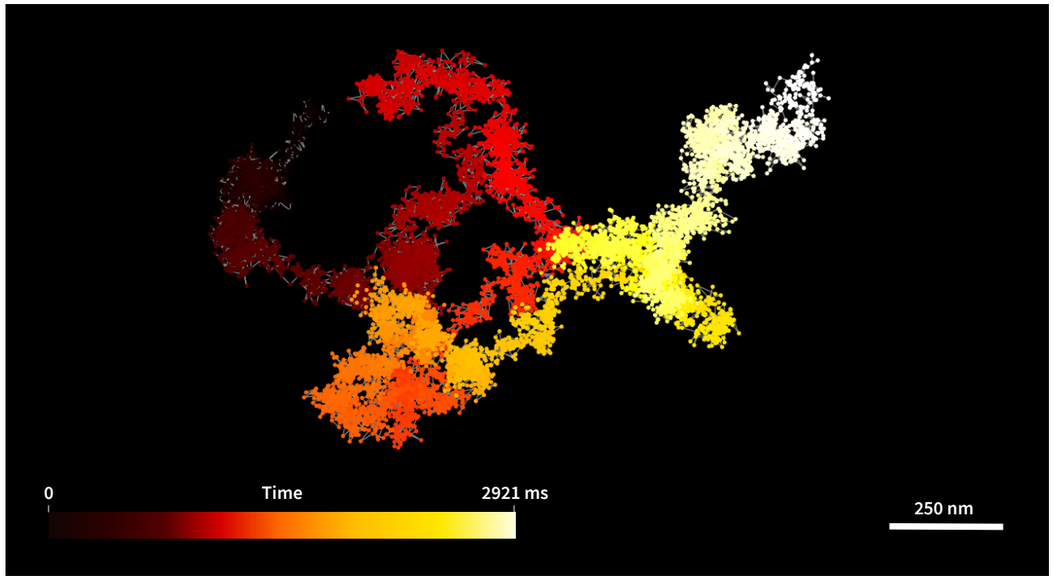
> 30.000 localizations

Unprecedented tracking frequency at resolutions not reachable with any other (camera-based) tracking method.

In addition to achieving molecular-scale resolutions (1-3 nm) on large fields of view (10 x 15 µm FOV), MINFLUX tracks molecular movements at frequencies up to 10 kHz, resolving molecular motions every 100 µs.

MINFLUX tracks 100 times faster than conventional camera-based methods. Due to the low number of photons required for each localization, single molecules can be tracked with unprecedented spatio-temporal resolution (e.g. 28.000 localizations each at 20 nm resolution).

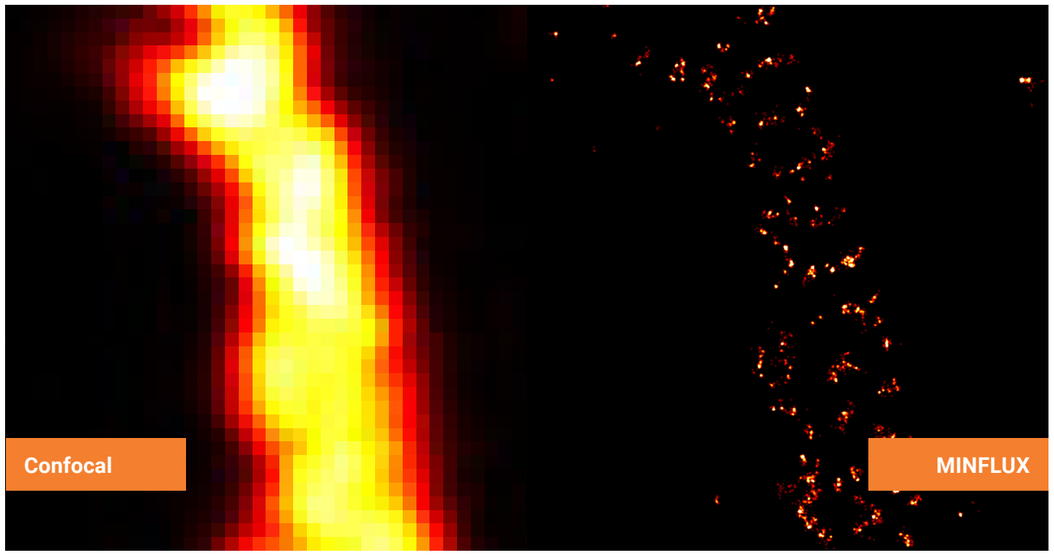
Choose between MINFLUX molecular imaging and tracking at the push of a button!



2D MINFLUX tracking of a single lipid-coupled Atto647N fluorescence molecule in a lipid bilayer. Note the high precision (20 nm) and high number of data points (28.000) in this ~ 3 seconds long trace.

MINFLUX molecular imaging
100 times sharper
than confocal microscopy

MINFLUX (minimal fluorescence flux) is the most precise and most photon-efficient way of localizing fluorescent molecules. With its new MINFLUX system, Abberior Instruments has produced the first commercial fluorescence nanoscope that can achieve 3D-spatial **resolutions of 1-3 nm** in biological samples.



MINFLUX image of axonal bII spectrin in primary hippocampal neurons with < 2 nm resolution. Note the periodic arrangement of spectrin along the axon, and the absence of any details in the confocal counterpart image.

Super-resolution imaging has overcome the 200-300nm diffraction resolution barrier, providing astonishing new insights about the complexities of cellular structures and functions over the past two decades. Standard super-resolution methods allow for spatial resolutions of approximately 20-30 nm.

Although hugely impactful, previous methods have failed to achieve resolutions on the 2-3 nm scale of the fluorescent molecules themselves. Harnessing an entirely new and revolutionary localization principle, MINFLUX has finally accomplished this feat, exhibiting a resolution leap of 10-fold compared to other super-resolution methods and 100-fold compared to confocal fluorescence imaging.

RESOLUTION

1-3 nm in 2D

2-5 nm in 3D

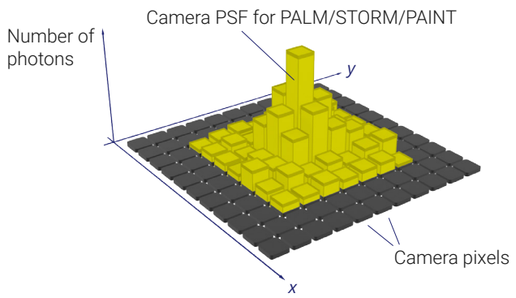
Unprecedented molecular resolution and fidelity, not attainable with any other super resolution method.

MINFLUX - a *resolutionary* concept

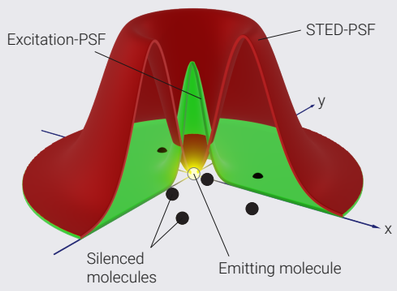
Watch our MINFLUX explanation video online!

Super-resolution methods discern adjacent fluorescent molecules by reducing the number of simultaneously-active emitters, allowing for their emitted photons to be detected separately. Each approach practically achieves this in a different way.

Approaches including PALM, STORM, and PAINT rely on the localization of single fluorescent molecules, whereby the molecular position is established by calculating the maximum of its fluorescence spot produced on a camera. This 'centroid-based' localization rarely exceeds a precision of 20 nm for several reasons. Firstly, many molecules bleach before rendering the hundreds or even thousands of photons required for better precisions. Furthermore, the unknown orientation and tumbling of the emitting molecule compromises the accuracy of the spot on the camera. Long recording times allow both the molecules in a sample and the sample itself to drift in space. Additionally, a sizable fraction of the molecules are not localized at all because they fade out long before having rendered the large photon numbers needed for camera-based localizations.



In PALM/STORM/PAINT, high resolutions are only achievable with large numbers of detected photons (up to thousands). Long recording times, camera background, and molecular tumbling all introduce error.

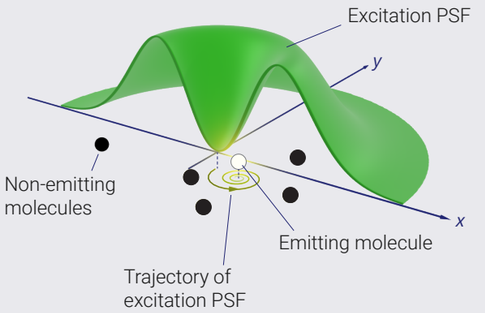


In STED microscopy, the resolution is entirely defined by the STED-donut. While the resolution is limited by the maximum donut intensity tolerated by the fluorophores, much fewer fluorescence photons are needed since, unlike in PALM/STORM/PAINT, the molecule's location is entirely determined by the position of the donut.

In STED microscopy (left), a donut-shaped de-excitation beam prevents the emission of all molecules peripheral to those located at the very center of the donut where the donut-intensity is minimal. Thus, emitting molecules must be very near the donut center. Advantageously, the detection of just a few fluorescence photons is enough to know that there is (at least) a single molecule at the donut center. Since the emission position is defined by the donut, using a donut eliminates the need for detecting hundreds or thousands of photons such as in camera-based localization methods. Thus, confocal background suppression also becomes possible. However, resolutions < 20 nm require high donut-intensities, leading to bleaching of fluorescent molecules.

MINFLUX nanoscopy defines an entirely new class of super-resolution methods that uses the best of both worlds: 1) Emitters are activated one-at-a-time to obtain the best molecule separation possible, 2) Localization is performed with a fluorescence excitation donut, fundamentally reducing the number of emitted photons required for ultimate localization precision. The central intensity-zero of the excitation donut-beam searches for the emitting molecule by performing a clever sequence of sub-nm sized probing steps. The closer the donut-zero is to the molecule, the lower the resulting fluorescence. By optimizing for low emission rates, the donut zooms in on the molecule, concomitantly increasing the precision with which the molecular position is known.

Thus, MINimizing fluorescence FLUXes by matching the donut-center with the molecule's position, localizes molecules reliably and with 1-3 nanometer precision! By relying on emission minimization rather than maximization, MINFLUX localization is: i) inherently fast, ii) does not discard weakly emitting molecules, iii) minimizes bleaching, and iv) is less drift dependent. Inaccuracies due to unknown molecular orientations and tumbling that severely compromise camera-based spot-centroid localization are ruled out.

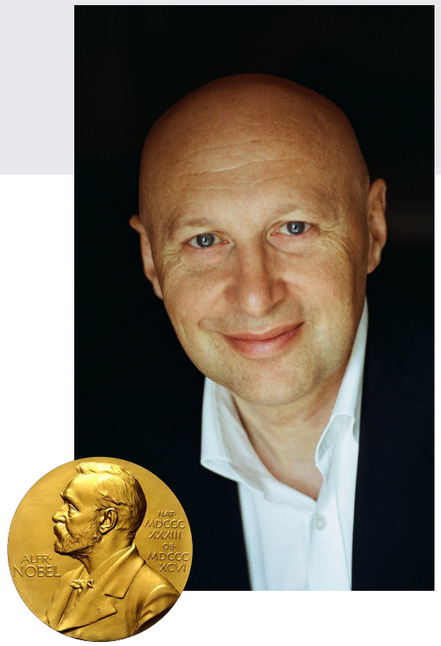


With MINFLUX microscopy, localization is performed by probing the position of fluorescent molecules with the intensity zero point of a donut-shaped excitation beam. This procedure reduces the number of fluorescent photons required for nanometer-precise localization by orders of magnitudes.

"Providing a spatial resolution at the scale of the molecules themselves, MINFLUX will be a key method for unraveling the spatio-temporal distribution of biomolecules in fixed and living cells in the 21st century."

Stefan W. Hell

Inventor of MINFLUX. Nobel Prize in Chemistry (2014) "for the development of super-resolved fluorescence microscopy"



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MINFLUX - made for **revolution**

The scientists and developers at Abberior Instruments understand the importance of smooth and simple operation when performing biological research. To maximize usability, we built our MINFLUX system with reliable and time-tested elements assembled on a robust optical breadboard. We use rock-solid opto-mechanical building blocks that have been proven to function seamlessly in hundreds of Abberior microscopes all around the world.

Moreover, in line with our design philosophy for top-of-the-line instruments, our MINFLUX systems are future-proof: they are designed to allow adaptations with the latest technologies available, maximizing performance in perpetuity.

Our MINFLUX system is built around a standard microscope body, providing a variety of options ranging from widefield fluorescence, DIC, phase contrast over confocal and STED, all the way up to MINFLUX.

In our MINFLUX systems we use our proprietary cutting-edge beam-scanning and -shaping technologies. Beam-shaping is performed with our easy3D technology, which delivers precision-tunable phase masks and aberration correction. Spectral laser coupling is highly selective and is fully removed from the beam path when not in use (100% transmission). The QUADScanner ensures perfect beam positioning. Rainbow spectral detection guarantees minimal losses and maximal spectral freedom. Furthermore, the APD-based detection system delivers maximum quantum efficiency (> 65 % in the red).

For the MINFLUX operation we have integrated two unique cutting-edge technologies:

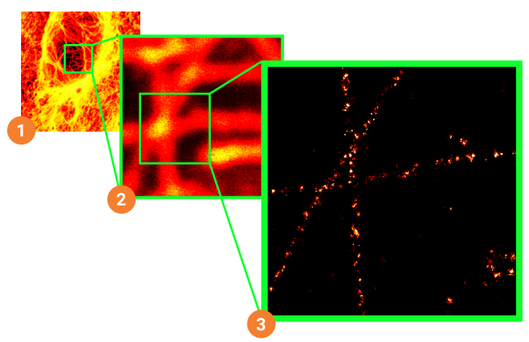
Electro-optical scanning for ultrafast sub-nanometer precise beam-positioning at the unprecedented line frequency of 100 kHz, and

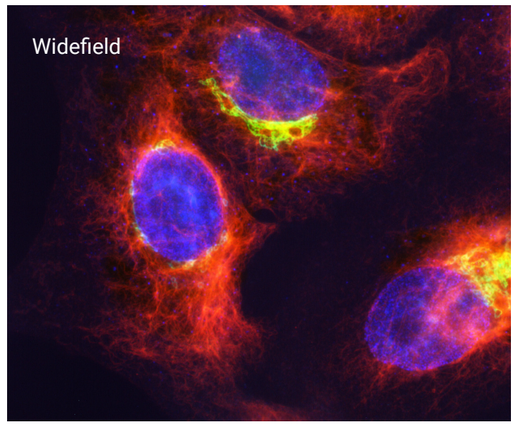
A deformable mirror for ultrafast z-scanning at several kHz.

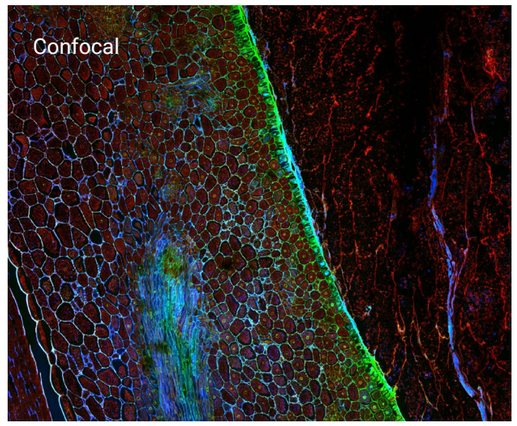
When performing experiments with nanometer resolution, miniscule sample drifts and movements can compromise performance. That's why our MINFLUX nanoscope comes with active sub-nanometer stabilization technology. When MINFLUX imaging is performed, a fully automated stabilization system based on laser-illuminated fiducial markers keeps the sample perfectly still over tens of minutes, with residual fluctuations < 1 nm in 3D.

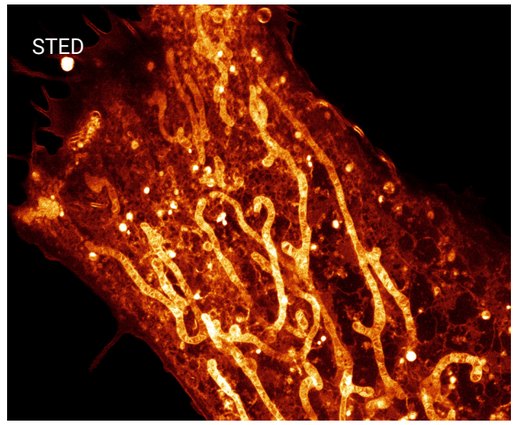
Finally, our MINFLUX nanoscope provides an easy-to-use, highly effective workflow. MINFLUX imaging can be done in just three simple steps:

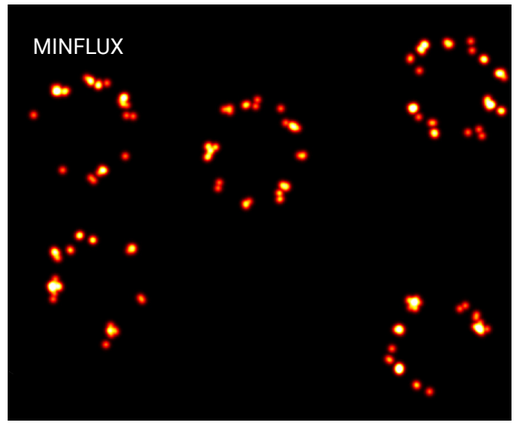
1. make overview scans
2. define regions of interest and
3. start MINFLUX imaging on fields of up to tens of microns in size.











Any traditional imaging modalities can be added to the system, including fluorescence widefield, epi-fluorescence, confocal, and STED imaging. This unprecedented array of possibilities allows you to image on length scales from micrometers to nanometers, all with a single system.

MINFLUX is the ultimate super-resolution fluorescence microscope!

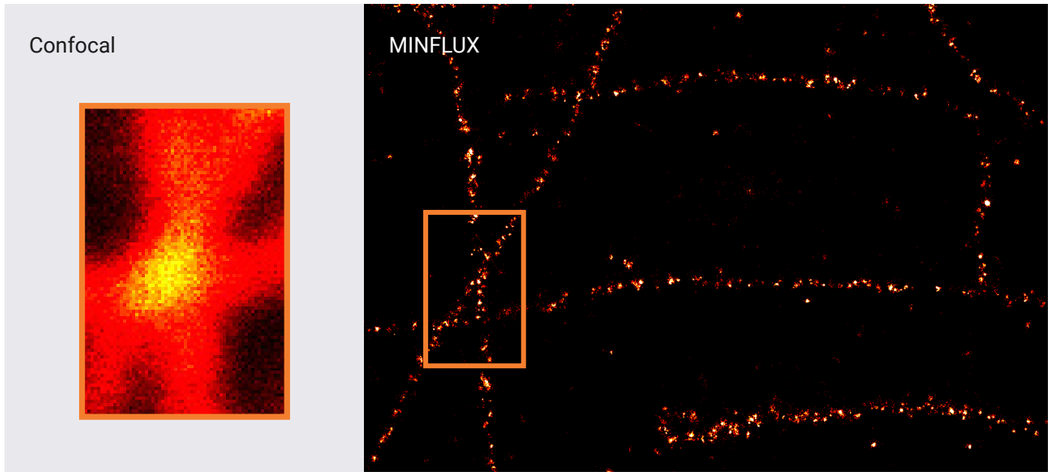
Excel on all scales with epifluorescence, confocal, STED, and MINFLUX.

Enjoy our portfolio of best-in-class STED nanoscopy technology from our Facility-Line microscopy system: – pulsed STED lasers provide vastly superior resolution than any cw-STED method per average illumination power. Besides, our MINFLUX system provides full gating functionality, full spectral detection, superior APD detection sensitivity, adaptive illumination for STED and confocal for live-cell imaging, easy3D STED with a superior zero light-minimum technology, adaptive optics for deep-tissue imaging, hardware autofocus for STED, autoalignment of all beams and pinhole, STED FLIM, and many powerful features...

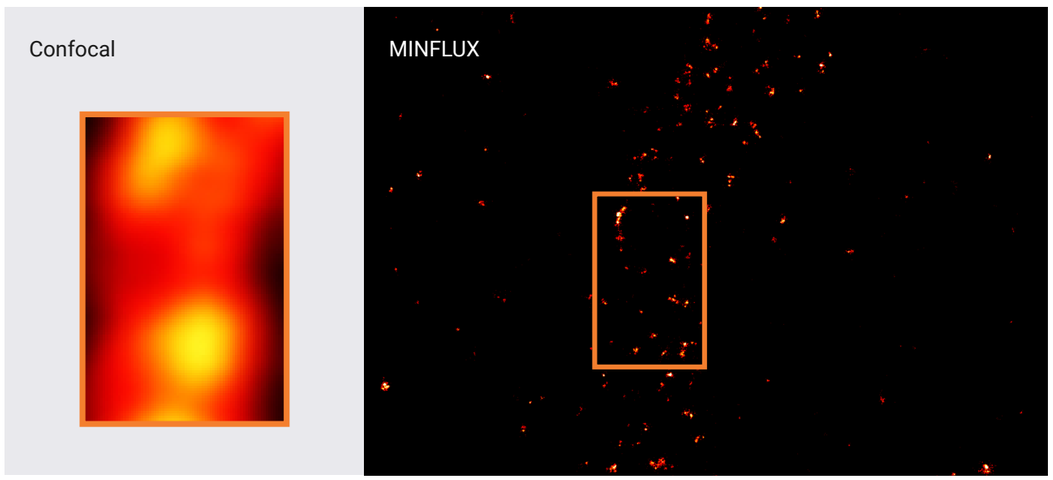
MINFLUX

a factor of **100**

makes all the difference



Confocal and 2D MINFLUX imaging of intermediate filaments. The vimentin network in cultured mammalian cells was immunolabelled using Alexa647.



Confocal and 2D MINFLUX imaging of mitochondrial proteins. The outer membrane protein Tom20 was immunolabelled using Alexa647.

> 100 kHz line frequency
Scan 100 times faster than any other method

1-3 nm localization precision
Resolve 100 times better than confocal microscopy

100 µs time per localization
Track fluorophores 100 times faster than with a camera

References

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Eilers, Y.; Ta, H.; Gwosch, K.; Balzarotti, F.; Hell, S.W.: "MINFLUX monitors rapid molecular jumps with superior spatiotemporal resolution". PNAS 115 (24) (2018)

Gwosch, K.; Pape, J. K.; Balzarotti, F.; Hoess, P.; Ellenberg, J.; Ries, J.; Hell, S. W.: „MINFLUX nanoscopy delivers 3D multicolor nanometer resolution in cells". Nature Methods 17 (2020)

The MINFLUX technology is protected by numerous patents, e.g. DE 10 2011 055 367 B4, EP 2 780 694 B1, CN 103930769 B, JP 6078889 B2, RU 2 610 928 C2, US 9,291,562 B2, EP 3 055 674 B1, EP 3 055 674 B1, CN 105637348 B, JP 6440037 B2, RU 2 662 461 C2, DE 10 2013 114 860 B3, CN 106030287 B, JP 6452005 B2, US 9,719,928 B2, RU 2 660 301 C2, DE 10 2016 119 263 B4, DE 10 2016 119 262 B4, DE 10 2016 119 262 B4, DE 10 2017 104 736 B3. Abberior Instruments has exclusively licensed patent rights from Max Planck Innovation GmbH. Further patent applications are pending.

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STEP AWARD

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MINFLUX

by a unique company

Abberior Instruments is a spin-off from Prof. Stefan W. Hell's laboratory at the Max Planck Institute in Göttingen, Germany. Since its foundation in 2012, Abberior Instruments has become a world-leading innovator and manufacturer of cutting-edge super-resolution microscopes with more than 60 full-time employees in Germany, Switzerland and the USA. We are:

100% owned by scientists

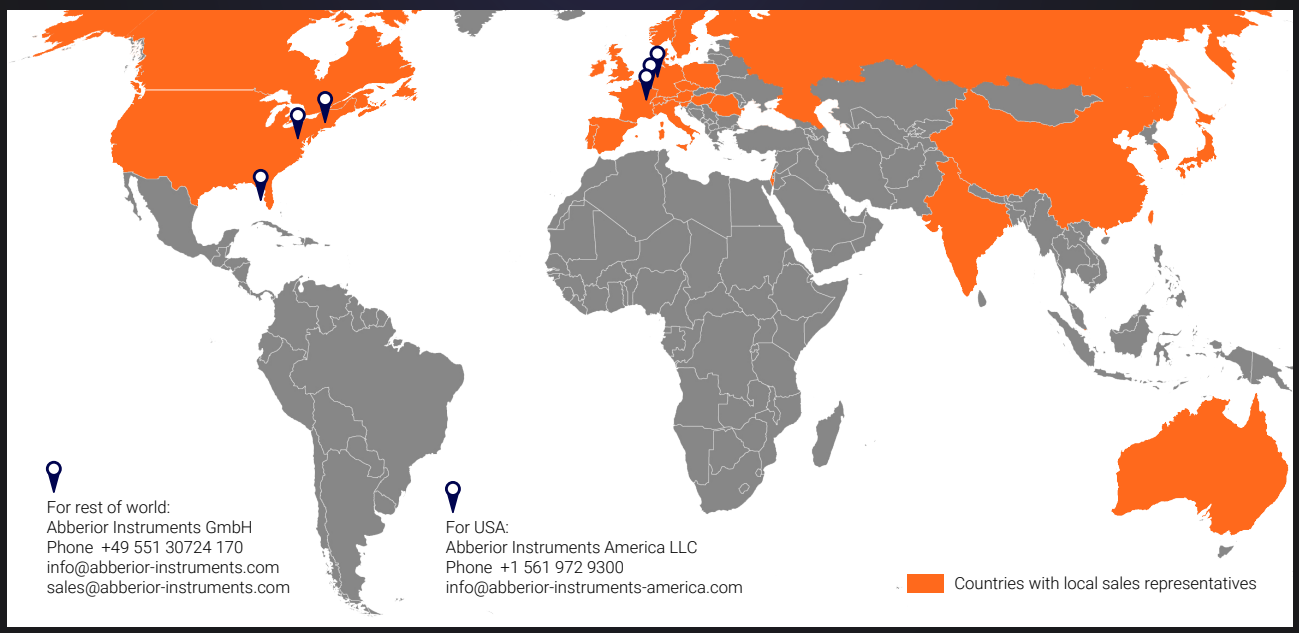
100% managed by scientists

100% controlled by the inventors and developers of STED, RESOLFT and MINFLUX

100% determined to advancing the life sciences to the benefit of humankind

Partner with us and be sure to get the best imaging solution possible today. We pledge to make the most powerful microscopes available, while not losing sight of versatility and ease-of-use. We honor your trust and understand that your purchase is a long-time investment. That's why we constantly offer upgrades and improvements. Don't get stuck with outdated, but well-marketed technology!

Don't hesitate **to collaborate with our world-class scientists and inventors!** Contact us today directly, or through our representatives worldwide.



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