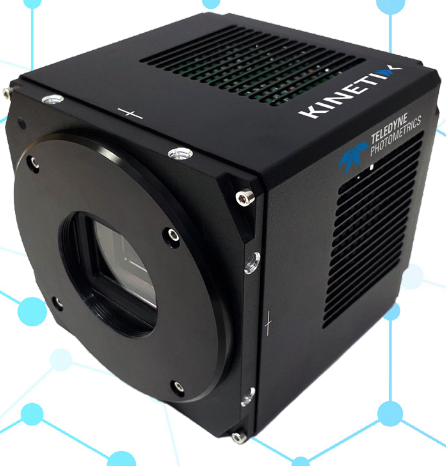
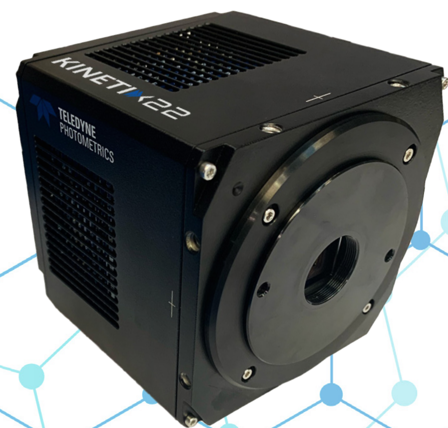
TELEDYNE | Teledyne Photometrics





KINETIX

KINETIX22

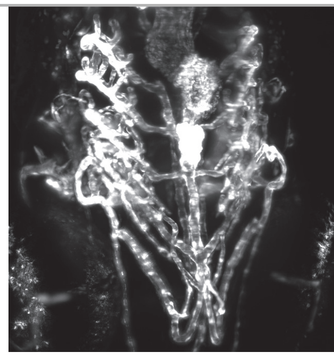
Kinetix Family Catalog

TELEDYNE PHOTOMETRICS Everywhereyoulook™

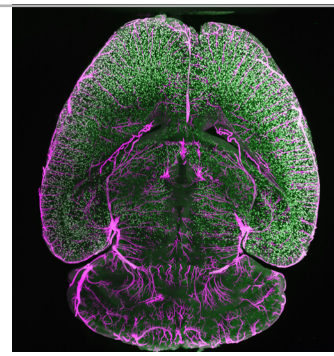
©Copyright 2021 Teledyne Photometrics
3440 East Britannia Drive
Tucson, Arizona 85706
Tel: +1 520.889.9933
Fax: +1 52 0.295.0299

Contents

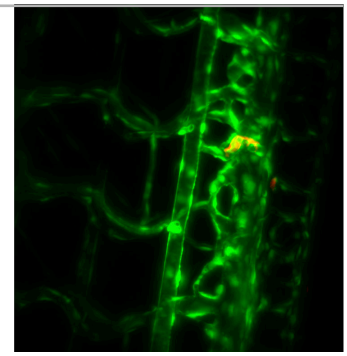
Light Sheet



Single frame of an OpenSPIM acquisition of a zebrafish.

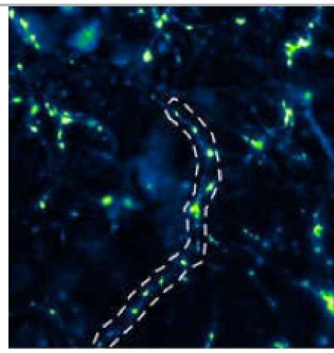


A full-frame max projection image of an iDISCO cleared APP/PS1 mouse brain.

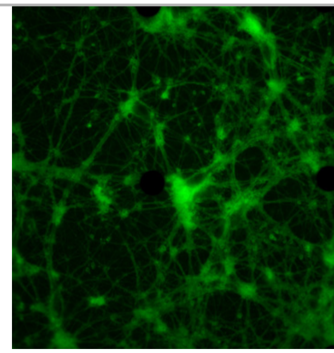


GFP expression in blood vessels within the developing zebrafish brain.

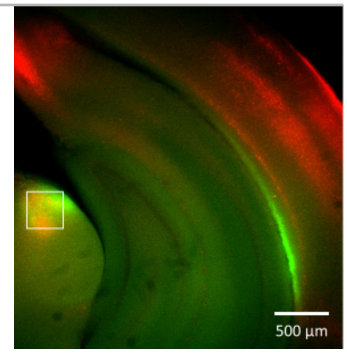
Neuroscience



Fluorescence imaging of the fluorescent reporter for vesicle cycling in hippocampal neurons.

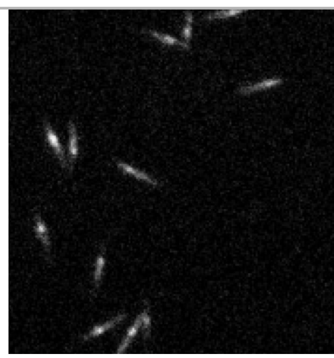


Voltage imaging with an MEA showing activity from the neuronal circuits.

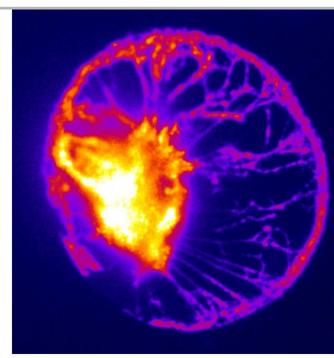


Dual fluorescence image of a live 300 µm thick coronal brain slice taken from an NTSR1-Cre mouse using a 4x air immersion objective.

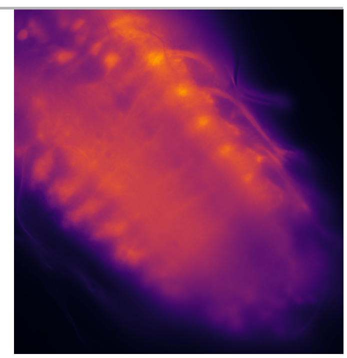
Calcium/ Voltage Imaging



Diatoms expressing R-GECO without stimulation (5 second exposure, background subtracted).

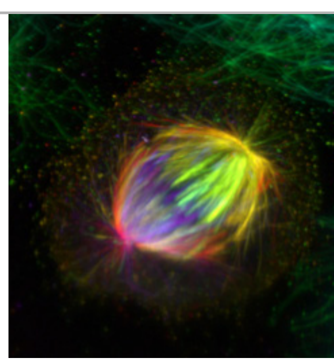


An image of glutamatergic neurons stained with the glutamate sensitive fluorescent reporter iGluSnFR.

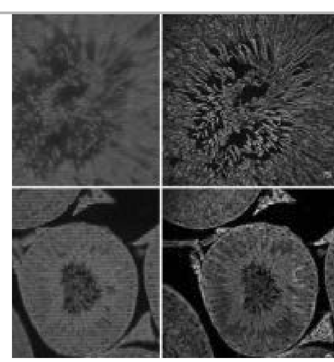


Ex vivo ventral nerve cord of a Drosophila larvae (L3) expressing GCaMP6f in all glutamatergic neurons.

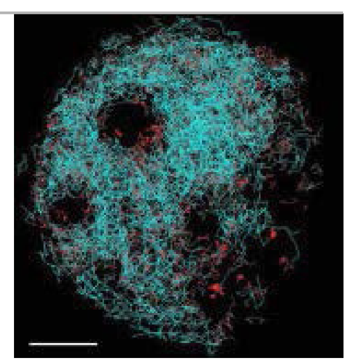
Super-Resolution



Super resolution image of fluorescently labelled microtubules.

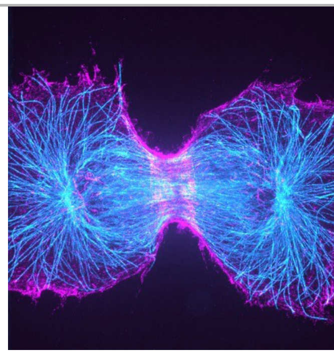


Cross section of a rabbit seminiferous tubule.

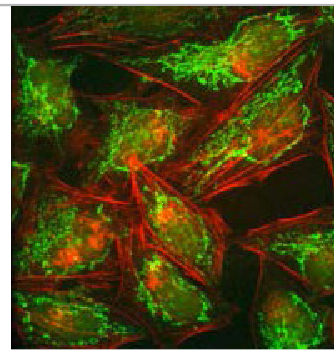


Human cell nucleus with DNA repair complex labelled with HaloTag-PA-JF549.

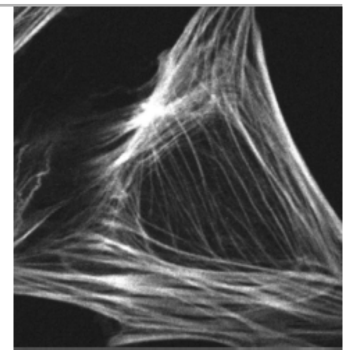
Spinning Disk Confocal



Expansion microscopy image of a dividing cell imaged on a spinning disc microscope.

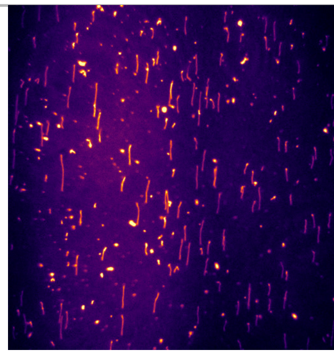


Mitochondria (green, 488nm) and Actin filaments (red, 566nm).

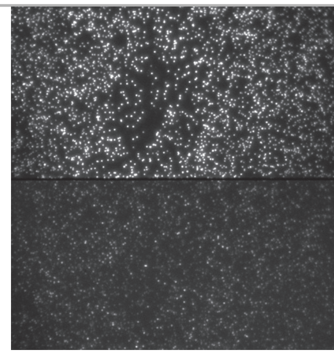


Actin cytoskeleton as stained by AlexaFluor488-Phalloidin

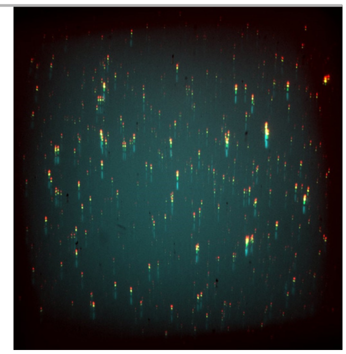
Single Molecule



Individual DNA strands tethered to a surface and stained with SYTOX orange.

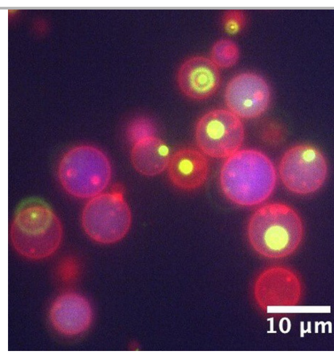


Donor and FRET signals separated to the top and bottom halves of the camera sensor.

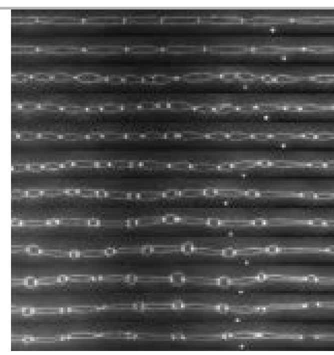


Representative false color FOV of 100 nm silica beads labeled with five different fluorescent dyes.

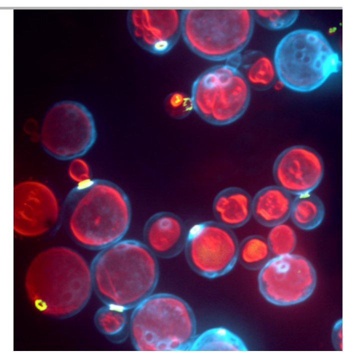
Live Cell Imaging



Unilamellar liposomes showingphase separated membraneless organelles formed within their lumen.



Expression of DLG-1:eGFP, apical junctional protein in the seam cell epithelium.



Yeast cells imaged with spinning disk confocal fluorescence microscopy.

High Content

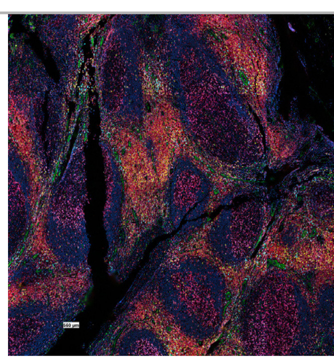
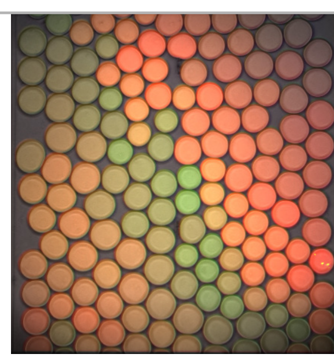
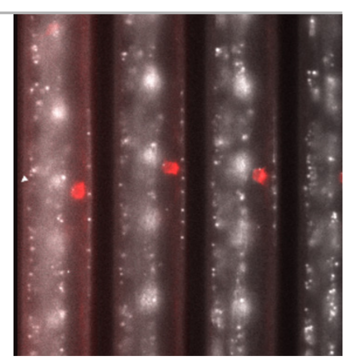


Image of tissue taken from the tonsil.



4 channel composite of an image from droplets in a microfluidic device moving under flow.



A single *C. elegans* worm imaged over time.

Kinetix Family: Applications

How Can Kinetix Enhance Your Imaging?

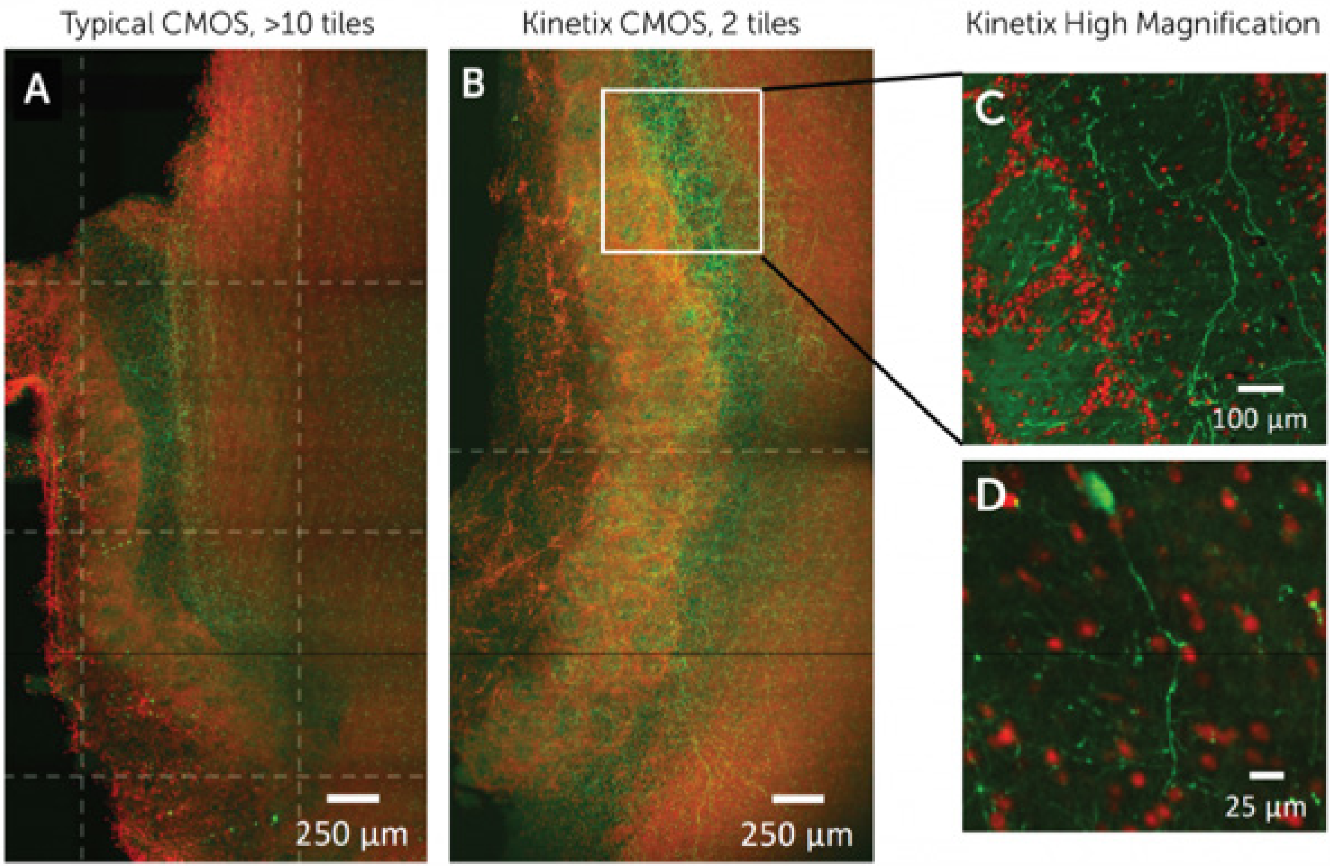
Light Sheet

Large Samples With Lower Light Dose

Customer Story: Prof. Ulrich Kubitscheck, University of Bonn

Prof. Ulrich Kubitscheck and Dr. Martin Schwarz of the University of Bonn (Germany) are working on an advanced application that allows super-resolution light sheet imaging of large samples at a low light dose. Light sheet fluorescence microscopy (LSFM) is combined with expansion microscopy, a technique that physically magnifies the sample to enable smaller features to move past the diffraction limit, resulting in LSFEM, used here to image the brain with multiple fluorophores.

Due to the expansion, LSFEM samples are huge and require a large FOV camera to avoid excessive tiling and stitching, as well as high resolution (to pick out small details) and high sensitivity (to reduce the light dose further and avoid bleaching during longer exposures).



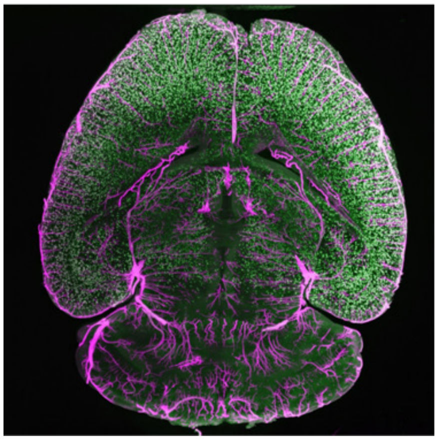
A brain tissue section imaged with LSFEM. Axons stained with EGFP (green). Nuclei stained with Hoechst (red). [A] Image acquired with a typical CMOS sensor, 12 separate images. [B] Image acquired using Teledyne Photometrics Kinetix sCMOS camera, only 2 tiles needed to cover the same region as [A]. [C-D] High magnification sections of white square from [B]. Images courtesy of Juan Eduardo Rodriguez-Gatica.

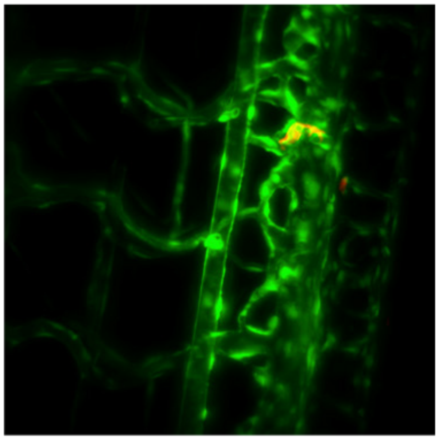
The large FOV, small pixel size, and high sensitivity of the Kinetix camera meets the needs of this demanding light sheet application. As explained by Prof. Kubitscheck, "The large sensor of the Kinetix greatly reduces the number of required image tiles to cover the field of view… and the signal-to-noise ratio is excellent."

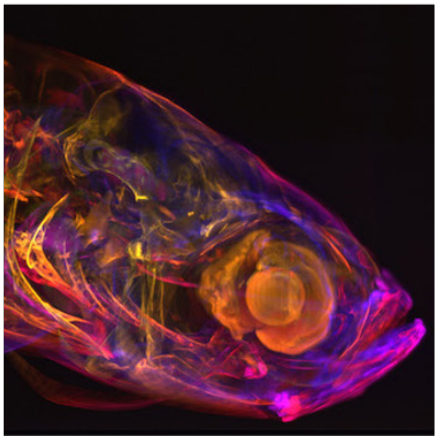
What Is Light Sheet?

Light sheet microscopy illuminates a 2D plane of the sample, which avoids excessive light dose and allows imaging over much longer time periods or imaging of light-sensitive samples. This also enables imaging of considerably large samples, such as whole organs and organisms. With large samples and low light both in play, cameras with large FOVs and high sensitivity are a must.

Light sheet is a highly adaptable application, featuring many variations of the core single plane illumination microscopy (SPIM), open-source libraries, modular add-ons, new advanced variations such as lattice/tiling light sheet, and even fusions with other applications such as swept confocally aligned planar excitation (SCAPE) microscopy. This highly adaptable application pairs best with powerful, highly adaptive cameras such as the Kinetix family.







Kinetix for Light Sheet Microscopy

Light results in a low light dose to the sample and physiologically friendly imaging. By lowering the light even more, samples can be imaged for hours or days using a sufficiently sensitive camera such as Kinetix (thanks to its high QE and low noise).

Many light sheet samples are larger than conventional microscopy samples, often centimeters or more. This is where a large FOV is vital to avoid excessive stitching and tiling. Here, the large FOV of the Kinetix camera is critical.

Finally, new light sheet techniques and emerging technologies also employ speed for high throughput imaging. The Kinetix family provides both faster frame rates and a higher data rate than previously available for many such techniques and technologies.

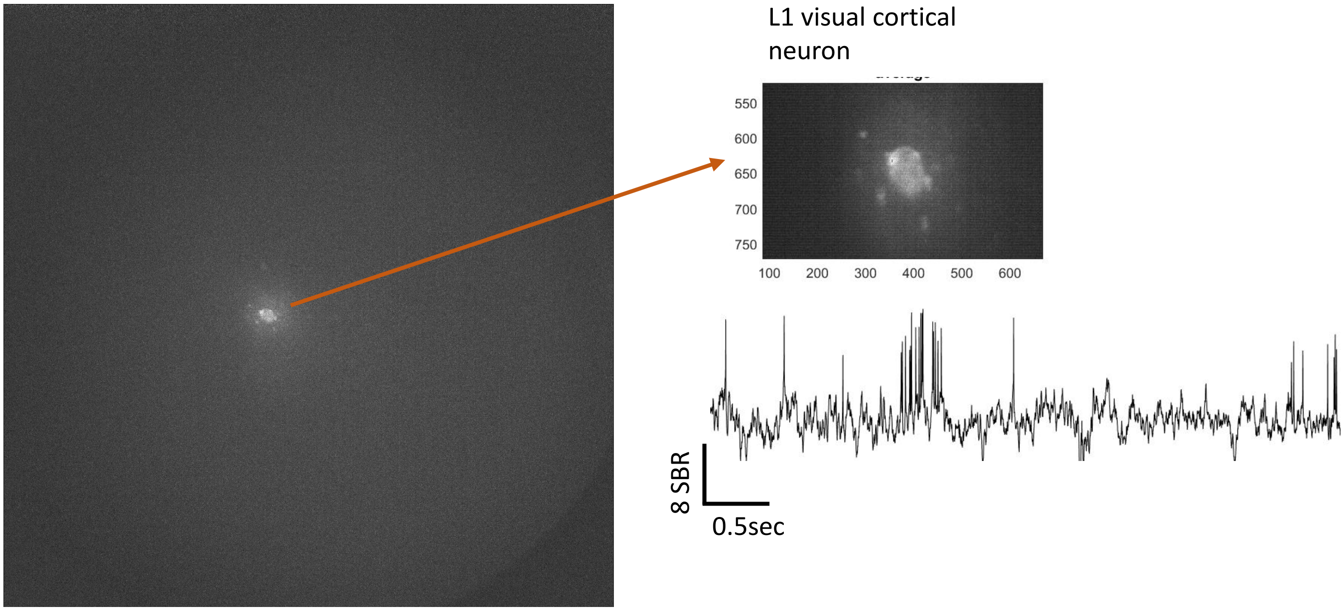
Voltage Imaging

Visualizing Dynamic Functionality

Customer Story: Prof. Xue Han, Boston University

The Han Lab in the Biomedical Engineering Department at Boston University (USA) designs novel neuromodulation therapies in order to eventually treat neurological and psychiatric disorders. This work involves using a wide range of neurological tools, including voltage imaging in samples ranging from cells to live organisms.

When performing voltage imaging, it is vital to operate a camera at high speed in order to capture membrane voltage activity within the brain. Typically, cameras attain such high speed by imaging a region of interest (ROI), which increases speed but reduces FOV. Kinetix cameras, however, can operate at high speed across the full FOV thanks to their speed mode, meaning there is no need for compromise. Kinetix offers high signal quality and the opportunity to image a large ROI at extremely high speeds, over 100,000 fps.



Voltage data from a single neuron at the center of the Kinetix FOV. Courtesy of Dr. Eric Lowet, Han Lab. This image is of a mouse visual cortex at the full FOV, recorded at 500 fps in speed mode at 40x magnification.

The Kinetix camera collects voltage data from neurons with a high signal-to-noise ratio (SNR) while operating at 500 fps across the full frame. This allows the Kinetix camera to image hundreds of neurons and collect voltage data from each, hugely increasing the throughput of experiments.

TELEDYNE IMAGING
Everywhereyoulook™

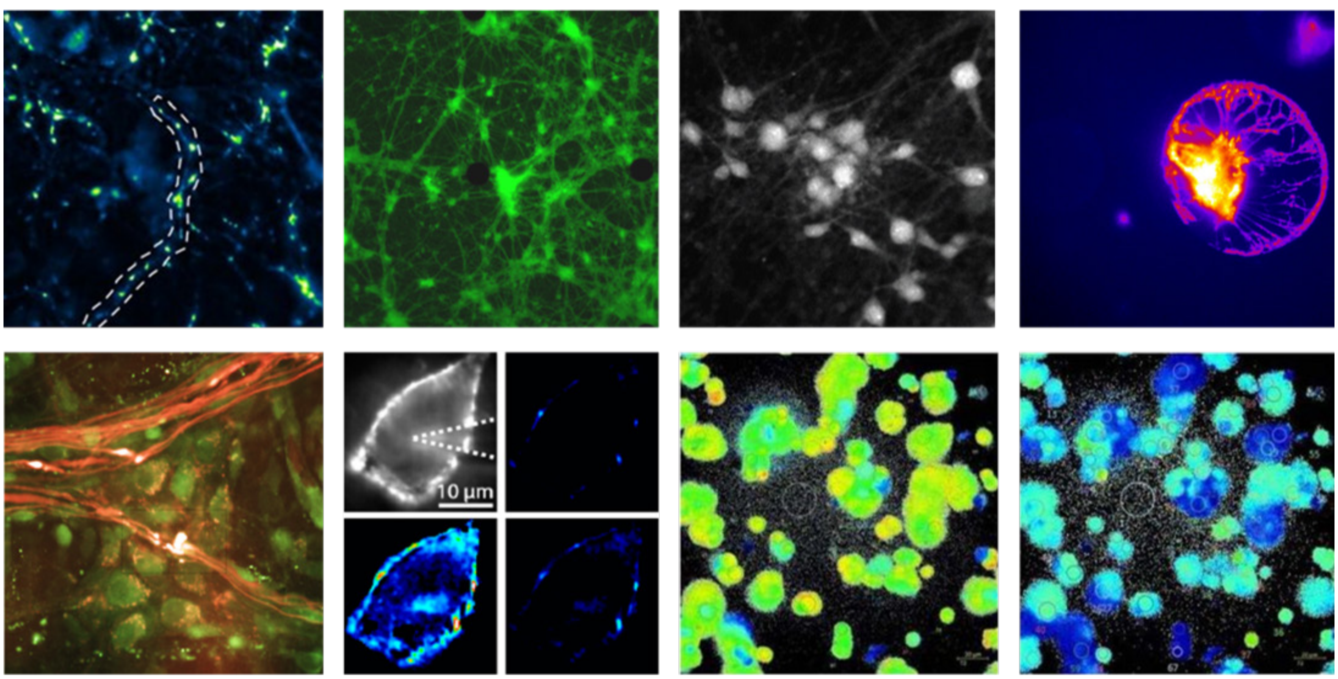
What is Voltage Imaging?

While imaging can reveal structural information about cells, it is vital to also consider imaging as a tool to measure functional information. Voltage imaging uses fluorescent molecules that bind to cell membranes and change fluorescence with the membrane voltage, allowing a solution where cameras can image functional electrical activity within brain and heart models.

Voltage imaging is a highly challenging technique, requiring extremely high speed due to the rapid kinetics at play, where there are millisecond changes in activity. This requires a very fast camera with high sensitivity so that exposure times can be lowered as much as possible. In addition, voltage imaging often looks at small fluctuations in activity, meaning a highly sensitive camera is also needed to detect these rapid, often weak, changes in intensity.

These cells are often networked; signaling can be influenced by their neighbors, making it necessary to image as many cells as possible at high speed. This requires a camera with a large FOV that can capture network activity.

The need for high speed, high sensitivity, and a large FOV makes voltage imaging well suited to the Kinetix family, next-generation cameras that can enable experiments previously not possible.



Super-Resolution

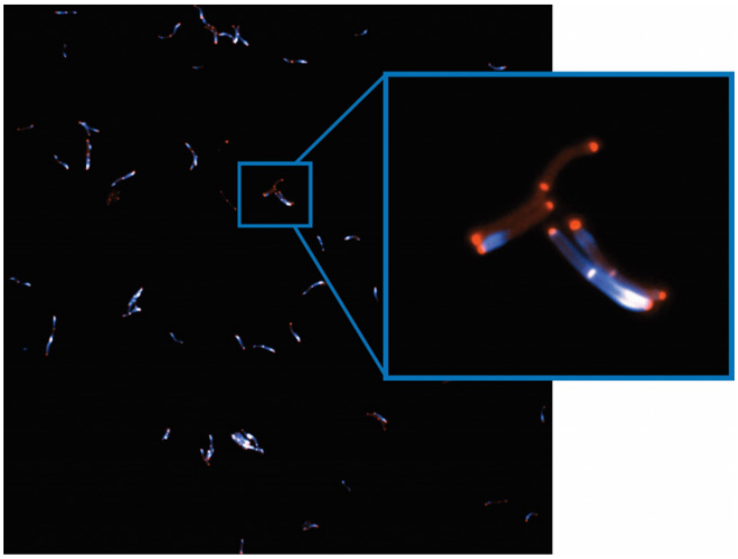
Resolving Nanoscale Details

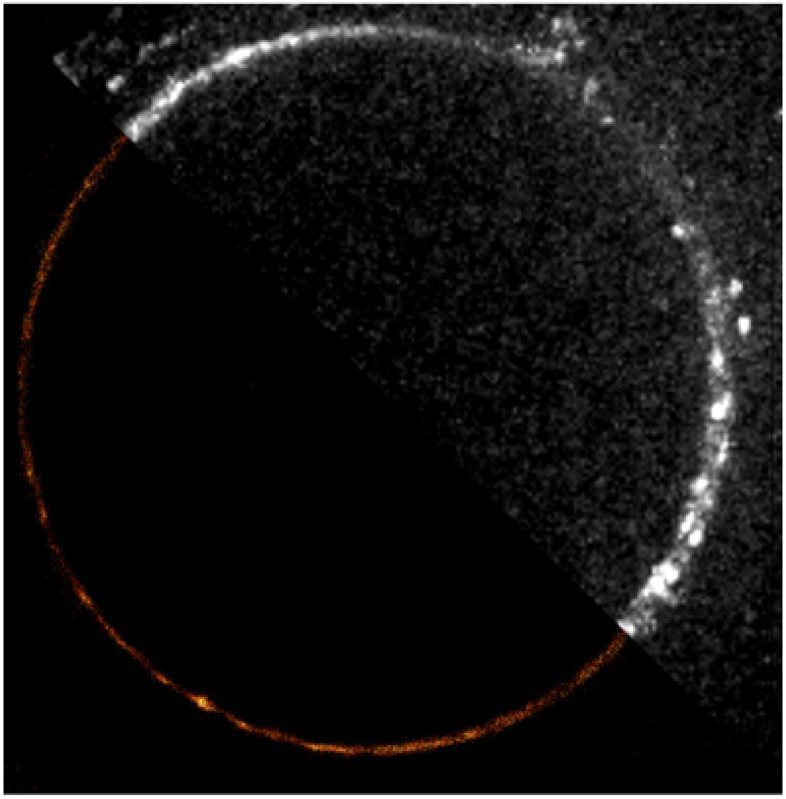
Customer Story: Prof. Suliana Manley, EPFL, Lausanne

At EPFL, Prof. Manley's team uses custom super-resolution imaging systems to study the cell cycle dynamics of bacteria with STORM and SIM.

These techniques require high sensitivity to detect enough fluorophores in the bacteria, as well as high speed and a large FOV to capture enough data. Few cameras can do it all, except for Kinetix.

Kinetix was easy to set up on the custom imaging systems and ran at a high speed across a large field of view, capturing data from even the low fluorescence of the bacteria.





Customer Story: Dr. Alexandre Fürstenberg, University of Geneva

Dr. Fürstenberg of Geneva develops novel fluorescent probes and is currently researching mechanosensitive fluorophores known as flippers, which are especially useful for studying membranes using dSTORM.

The samples here are giant unilamellar vesicles (GUVs), which feature a small membrane cross-section that results in low signal but are also large and require a big FOV camera to avoid stitching and tiling.

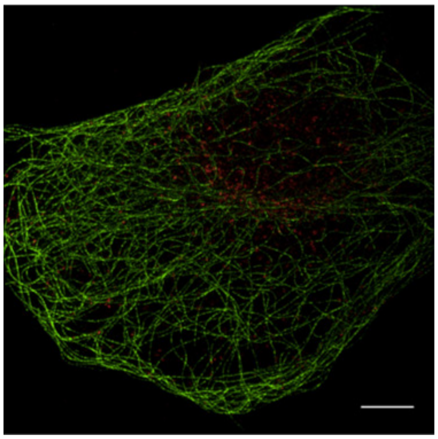
The large FOV of Kinetix can capture more of each GUV, and the camera's sCMOS technology means that samples don't have to be exactly centered in the field. Both were issues with previous EMCCD solutions.

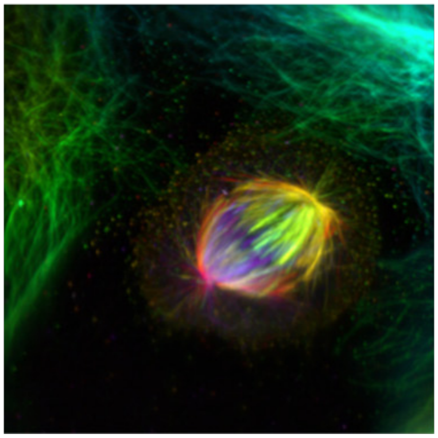
What is Super-Resolution?

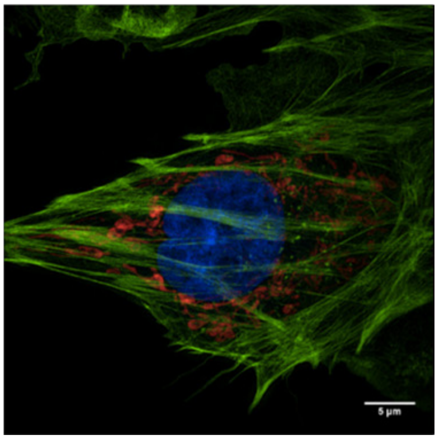
Super-resolution microscopy techniques can resolve structures beyond the diffraction limit of light, imaging samples at the nanoscale, down to single nanometer resolution. Super-resolution imaging reveals more information about biological structures than conventional light microscopy by allowing smaller features to be visualized, and in more detail.

There are multiple types of super-resolution microscopy techniques, each with their own advantages and disadvantages. Some examples include the single molecule localization microscopy (SMLM) techniques: Photoactivated Localization Microscopy (PALM), Stochastic Optical Resolution Microscopy (STORM), and DNA-based Point Accumulation for Imaging in Nanoscale Topography (DNA-PAINT), as well as techniques that use structured light, namely Structured Illumination Microscopy (SIM).

Kinetix is an ideal solution for super-resolution microscopy due to its small pixel size matching well to high resolution imaging, its high sensitivity capturing even the weakest signals, and its large FOV resulting in high throughput imaging and more data in every frame.







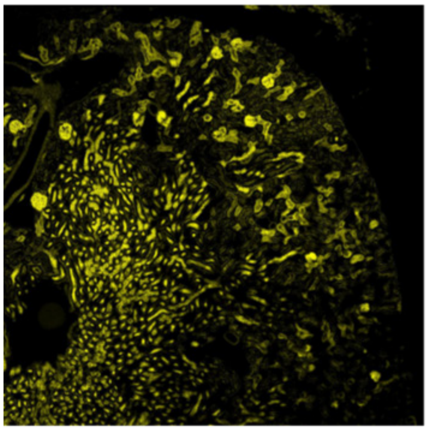
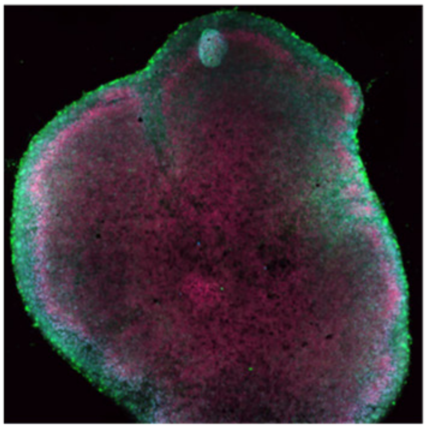
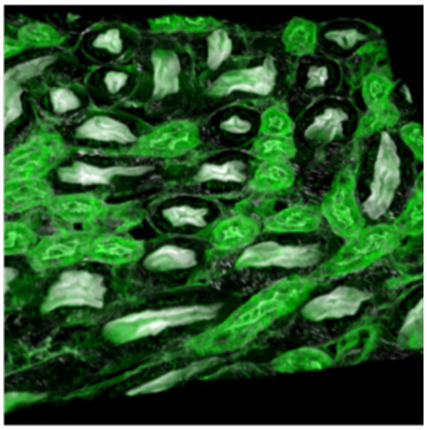
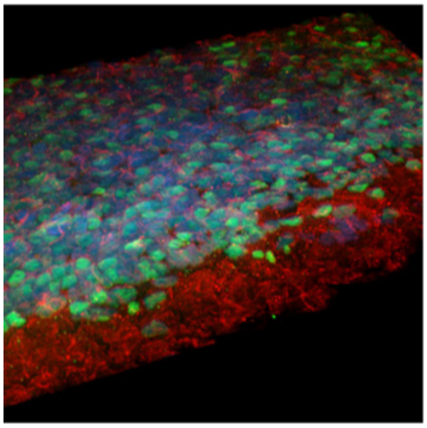
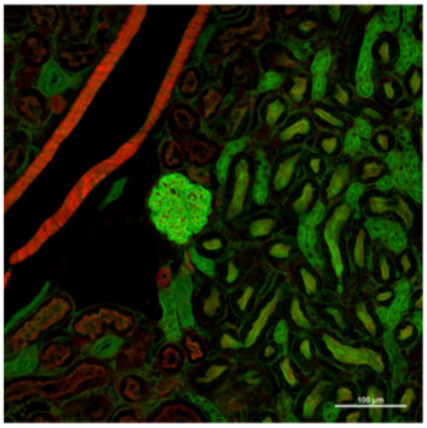
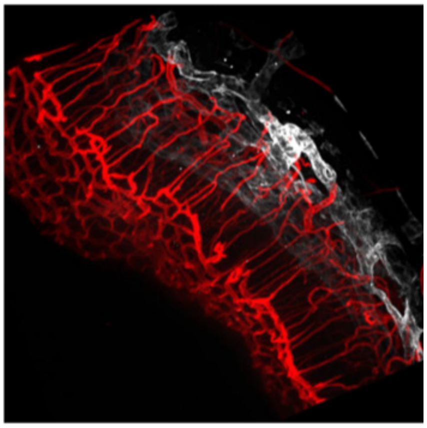
Spinning Disk

Confocality With Speed

Partner Story: CrestOptics X-Light V3

The high speed and large FOV of Kinetix requires an evolution in spinning disk confocal technology to make use of the camera's full potential, such as faster disks, variable pinholes, and large fields of illumination. These factors are all delivered by CrestOptics, a leading company in the development and manufacturing of advanced systems, and the creators of the X-Light V3 spinning disk confocal.

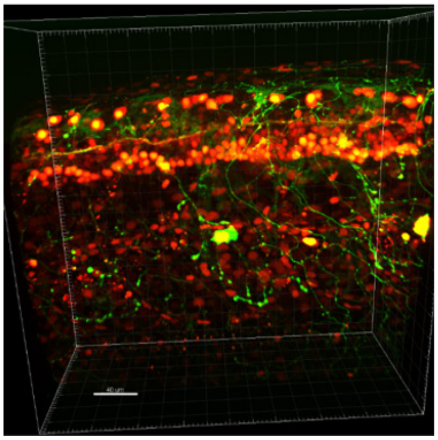
The combination of a Kinetix (or two) with the X-Light V3 results in a powerful imaging system that can deliver spinning disk confocal microscopy across large samples, at extreme speeds, and with uniform illumination. The images below were all taken with such an imaging system, demonstrating the ability to image at high and low magnifications, with multiple channels, across large samples in 3D, and with high resolution to discern features of interest.

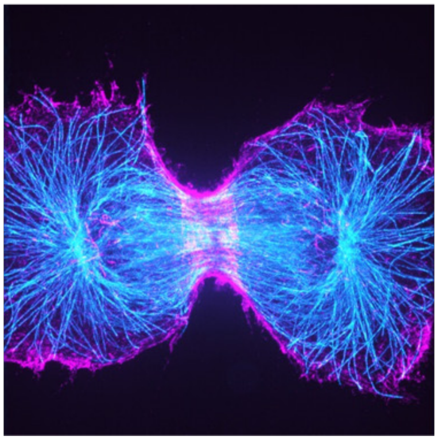







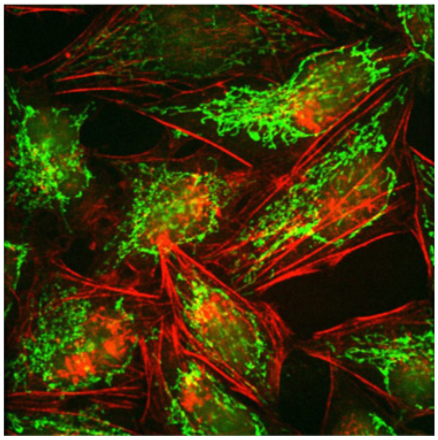
What is Spinning Disk?

Spinning disk confocal microscopy (SDCM) is an imaging technique often used with live cells and 3D samples due to its optical sectioning capabilities, high speed, and reduced photodamage. SDCM systems can also achieve super resolution and represent powerful imaging technology. But as SDCM is inherently a light-rejection technique, sensitive cameras are needed to maintain high image quality.

While SDCM systems of the past used EMCCDs, and more recently back-illuminated sCMOS sensors, the SDCM systems of the future will need higher speeds and larger FOVs. Kinetix is emerging as an ideal partner for SDCM, with confocal developers such as CrestOptics looking to large format sCMOS cameras that can capture large samples at high speeds without compromising resolution or sensitivity.







Kinetix for Spinning Disk Confocal Microscopy

Microscopes and spinning disk systems are continually increasing their FOV, allowing higher throughput and more efficient image capture. SDCM requires cameras with larger sensors that can capture all the information from the microscope, such as the large FOV Kinetix.

Disk speeds are also increasing. Some systems now spin up to 15,000 rpm, enabling capture of live dynamic systems at higher imaging speeds to collect more information. Therefore, higher speed cameras like the Kinetix family are needed to keep pace.

In addition, the small 6.5 µm pixel size of the Kinetix family allows high resolution image capture, providing a great match for high magnification super resolution SDCM systems or for experiments that involve very small samples.

TELEDYNE IMAGING
Everywhereyoulook™

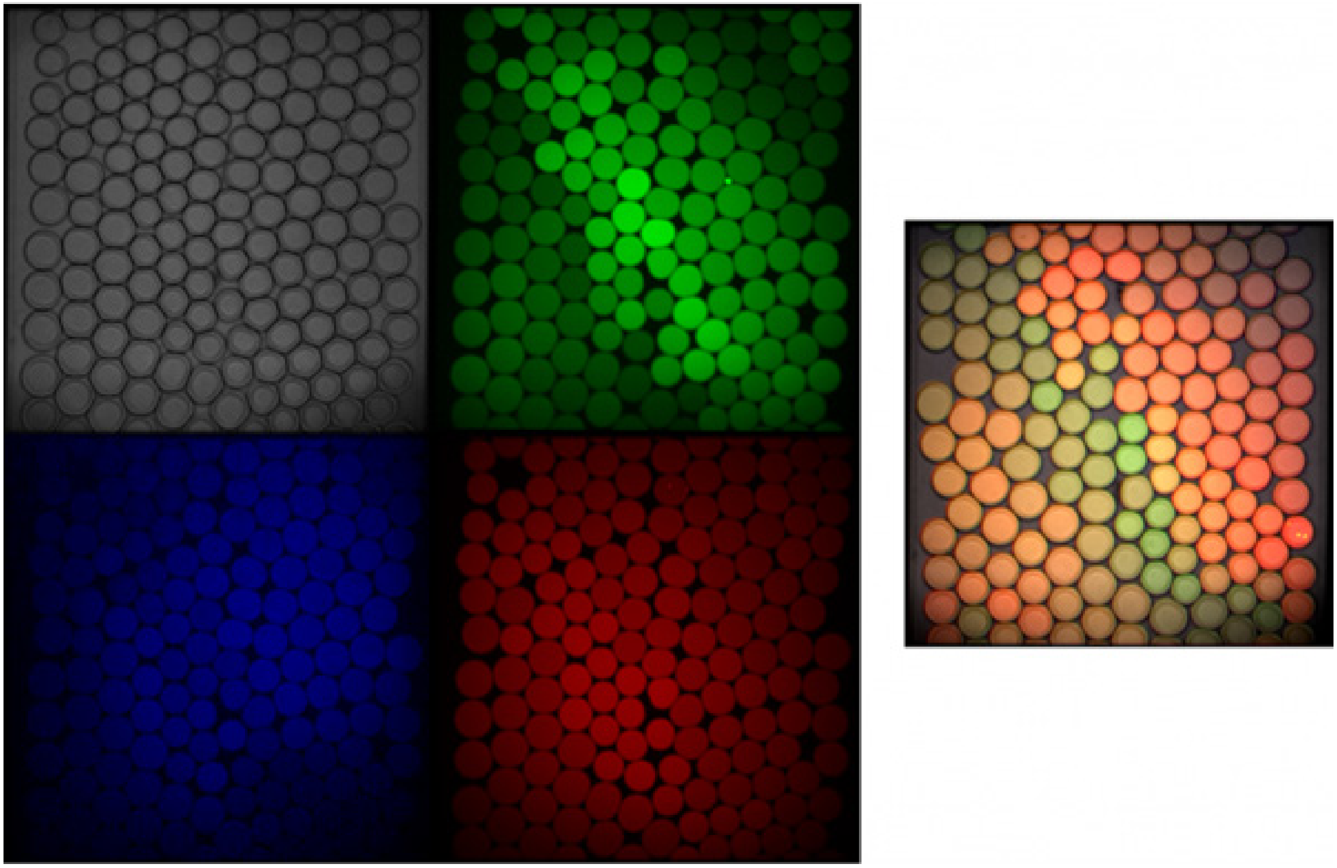
Multichannel

Simultaneous Multiwavelength Imaging

Customer Story: Dr. Georg Krainer, University Of Cambridge

The Knowles Lab at the University of Cambridge (UK) develops new approaches to probe the behavior of biological molecules, especially protein self-assembly. Dr. Georg Krainer and Dr. William Arter use custom microfluidic imaging systems to study these proteins, with fluid droplets labeled with several different fluorescent markers moving at high speed.

The main challenge is obtaining stable images of molecules as they flow through the camera FOV, making a high speed camera necessary. This dynamic imaging also requires a large FOV split into several different fluorescent channels with high sensitivity, due to the low signal of the droplets. The solution? A Kinetix paired with a four-way splitter.



Droplets within a microfluidic device moving under flow, captured with a Kinetix paired to a Cairn MultiSplit, showing four channels simultaneously at high speed (left shows split, right combined).

The Kinetix camera allows high speed, high sensitivity imaging across four fluorescent/brightfield channels simultaneously, without compromising the field of view. This feat would typically require multiple cameras or significant time delay, but a Kinetix with an image emission splitter is a powerful combination, once again enabling experiments that were not possible before.

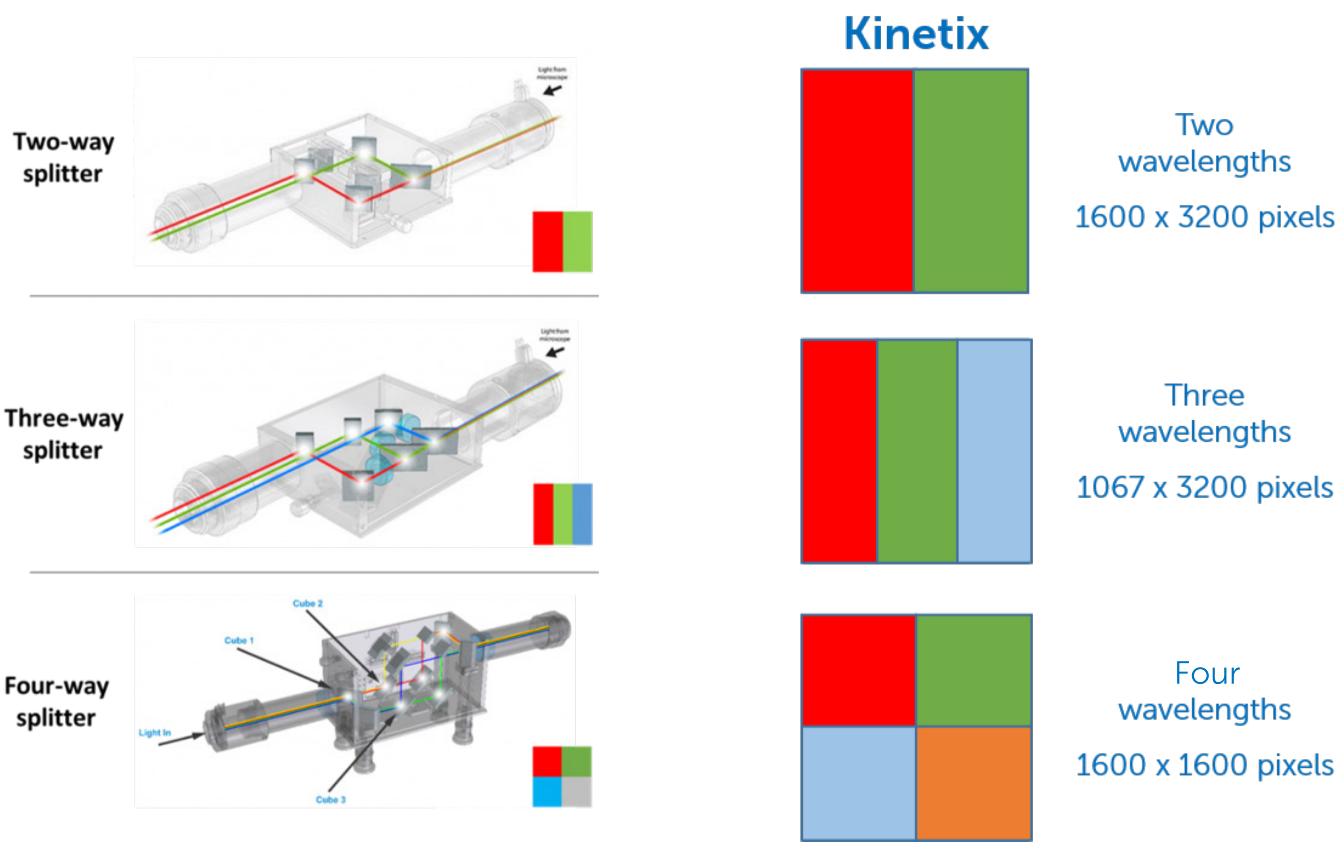
What is Multichannel?

Many experiments in microscopy involve imaging across multiple wavelengths in order to generate multichannel images, with each fluorescent channel (blue, green, red) labeling a protein or molecule of interest.

Typically, this type of experiment can involve a filter wheel to manually change the illumination wavelength; however, this is time consuming, and data can be missed while the microscope switches between channels. Electronic or automated filter systems cut down on the lost imaging time, but there is still inefficiency in this form of multichannel imaging.

The ideal solution is simultaneous multichannel imaging, where a single camera can capture multiple different wavelengths at the same time, with no time gap, using an image splitter. However, this typically reduces camera FOV to sizes where samples are more challenging to image. Only with a large FOV camera can image splitters and simultaneous multichannel imaging be done effectively, as with Kinetix.

Kinetix pairs well with four-way image splitters, such as the MultiSplit from Cairn Research. With a four-way split, each quarter of the Kinetix FOV is still ~15 mm diagonal, virtually the size of a typical CMOS device.



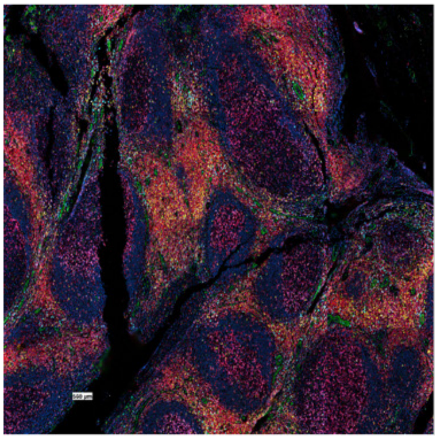
High Content Imaging

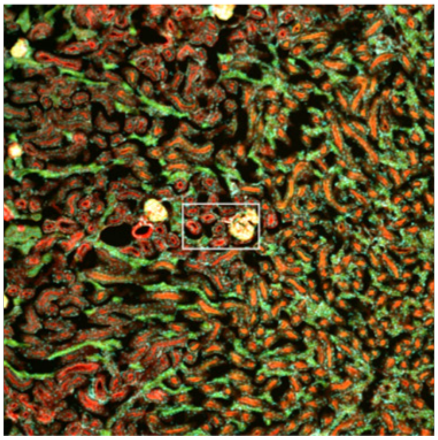
High Throughput Experimentation

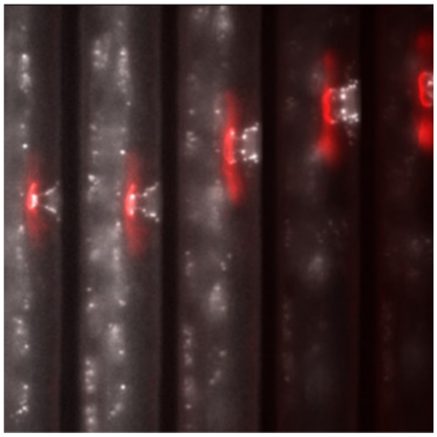
Introduction

High content imaging (HCI) aims to maximize data capture. HCI can involve automated imaging and quantitative data analysis in order to streamline experimentation and make imaging as efficient and high throughput as possible. The combination of custom-built imaging systems and powerful analysis software packages for HCI requires the use of an advanced camera with a large FOV and high speed to maximize data capture.

High resolution, high speed, and a large sensor are all required to optimize throughput and boost the data rate going to the PC, thereby increasing the HCI system's ultimate performance. High image quality is also a must to facilitate automatic software analysis of areas and features within the images, without any impact from artefacts or noise.







Kinetix for High Content Imaging

The Kinetix camera can operate at a data rate of over 5000 megapixels/second, thanks to the combination of a 10 megapixel sensor running at 500 fps (2850 megapixels/second for the Kinetix22). This rate enables easy capture of large volumes of data across a large FOV, ideal for high content applications.

The high quantum efficiency and low noise of the Kinetix family also result in great image quality and easy analysis of features within images. Advanced triggering allows effective pairing to light sources and the minimization of dark/dead time between images, further increasing efficacy and maximizing data capture.

Finally, the overall reliability offered by the Kinetix family is well suited to HCI, an approach concerned with performing imaging experiments thousands or millions of times to reach an effective sample size.

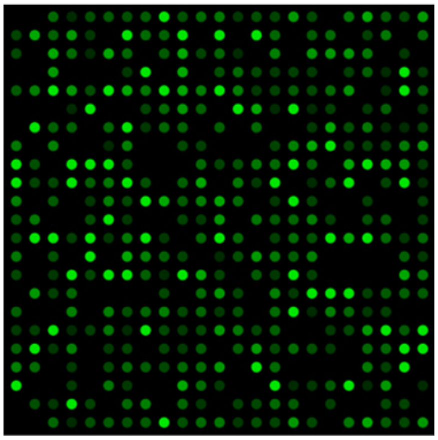
Spatial Omics

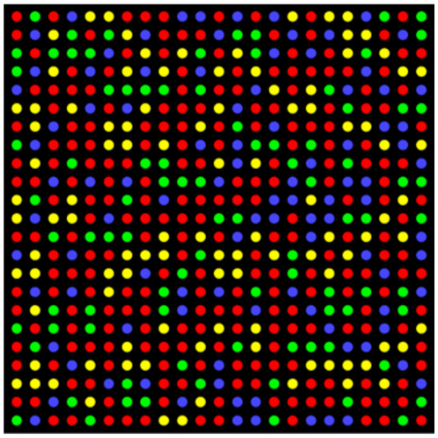
High Throughput Sequencing

Introduction

The term 'omics' refers collectively to the fields of genomics (DNA), transcriptomics (RNA), proteomics (proteins) and more, essentially covering molecular biology from DNA to RNA to proteins. While genetic sequencing can study the flow of information between these molecules, gene expression is spatial and can change across a tissue. This phenomenon has led to the field of spatial omics, where gene expression (and more) is imaged across biological samples using microscopy.

Spatial omics typically needs to use an imaging system capable of high resolution in order to acquire high quality positional information from tissue sections as well as identify genetic information. If the sample is live and in motion, high speed is required to capture dynamic movement. As always, high sensitivity is needed to detect changing signal levels.





Kinetix for Spatial Omics

The Kinetix camera is well suited to spatial omics, thanks to the combination of its sensor's large FOV and small pixels. The 10 million pixels allow high resolution imaging of enormous numbers of genetic or epigenetic permutations. The more that can be imaged at once, the more efficient these experiments can be. Some leading-edge spatial omics experiments can only be performed using the impressive size and resolution afforded by the Kinetix camera.

With both greater speed and larger sensors than typical sCMOS, the Kinetix greatly improves throughput. The 29 mm sensor is 2.5x larger than the 18 mm sensor of typical sCMOS, and when croppoed to a 2k pixel array, the Kinetix operates at over 700 fps, far faster than the 100 fps of typical sCMOS at this array size.

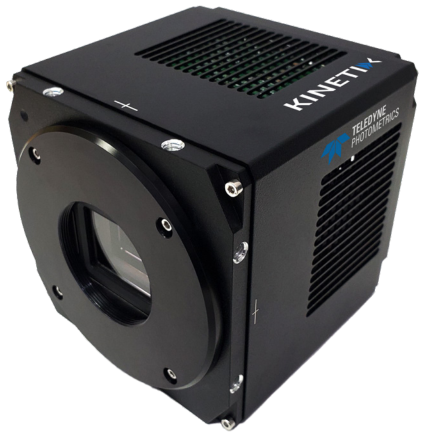
Positional and spatial information is vital for spatial omics. The Kinetix camera's Programmable Scan Mode lets users control line time and rolling shutter scan direction to maximize efficiency and capture as much information as possible.

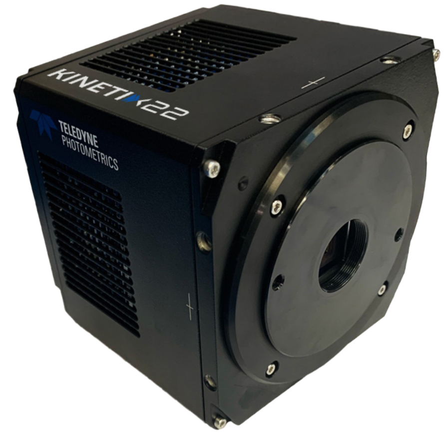
Kinetix Family: Features

Powerful Solutions For Your Science

The Kinetix sCMOS Family

Back-illuminated, High Speed





KINETIX

29 mm Field of View
10 megapixels

KINETIX22

22 mm Field of View
5.7 megapixels

Speed

The Kinetix camera family images at extremely high speeds, up to ~500 frames per second (fps), across the entire sensor -- and easily delivers from thousands to tens of thousands fps when imaging smaller regions of interest.

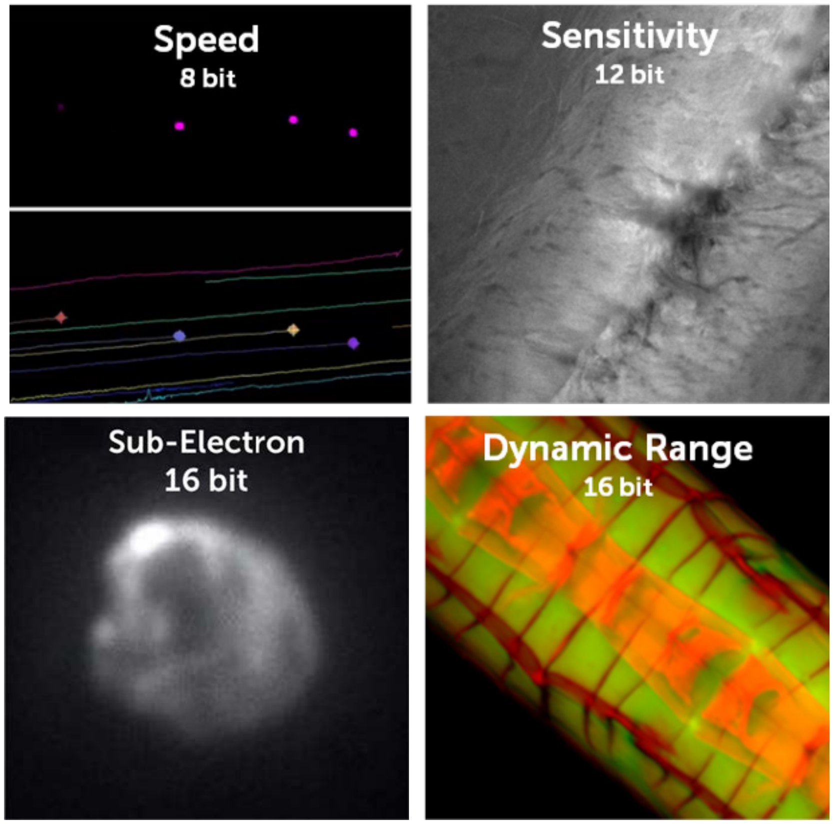
Sensitivity

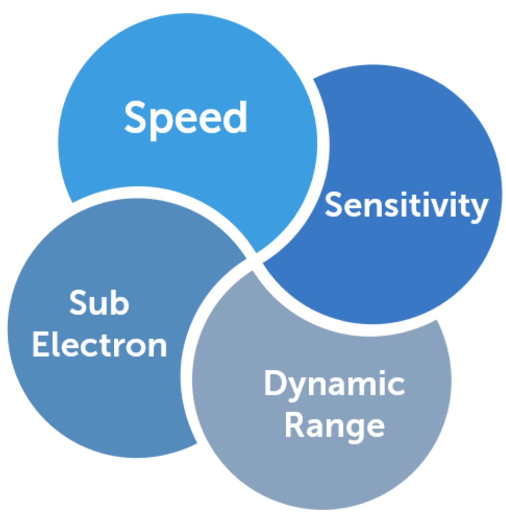
With near-perfect 95% quantum efficiency for maximal signal collection, as well as a special sub-electron mode for minimal read noise (0.7 e^- typical), the Kinetix Family allows high sensitivity imaging of even the weakest signals.

Resolution

The use of square 6.5 µm pixels results in high resolution imaging across a range of magnifications, making these cameras suitable for a wide variety of sample types.

Ultimate Flexibility with Four Modes





Speed

Achieve ~500 fps (full frame) in 8-bit mode readout

Sensitivity

Low 1.2 e^- read noise at 90 fps, fast and sensitive

Sub Electron

Minimal 0.7 e^- read noise at 5 fps to detect the weakest signals

Dynamic Range

16-bit mode for imaging both bright and dim samples together (at 83 fps)

Kinetix Family: Field Of View

Customer Story: Dr. Leonardo Sacconi

> “We switched to the Kinetix thanks to the large dimension and high resolution of the sensor, and of course we also really appreciate the high quantum efficiency provided by the back-illuminated technology.”

Dr. Leonardo Sacconi
Cardiac Imaging Group, National Institute of Optics, National Research Council, Italy

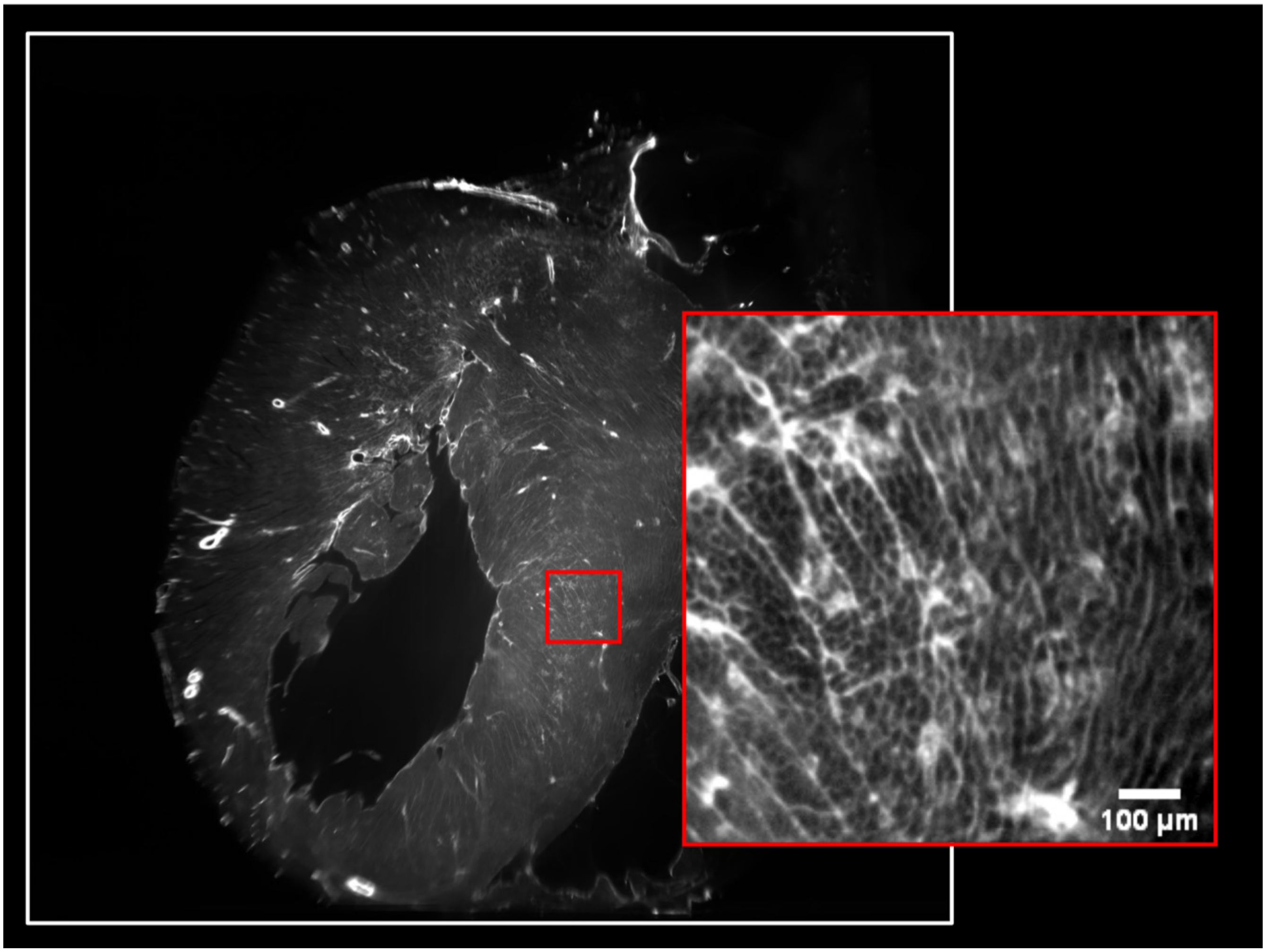


Figure 1: Preliminary image of a clarified (CLARITY based) mouse heart stained with an Alexa Fluor conjugated WGA using the mesoSPIM imaging system in combination with the Kinetix CMOS. The white square represents the full field of view of the camera, capturing the entire heart in one acquisition. The magnified red area represents the resolution at 2x magnification.

Background

Dr. Sacconi aims to develop novel imaging modalities for research into cardiovascular physiology and pathology, investigating both the structure and function of cardiac tissue. This work is done on entire mouse hearts in 3D, with hearts being optically cleared using CLARITY or SHIELD protocols. Using a newly developed light sheet system based on the mesoSPIM initiative, the large heart samples (~1 cm in diameter) can be imaged with an axially scanned light sheet to the resolution of 5 µm.

Challenge

The sample size is on the order of centimeters, as Dr. Sacconi is imaging entire cleared mouse hearts. This means a very large FOV is needed, otherwise experiments would involve long acquisition sessions with many images stitched together (also requiring large computational commitment). Dr. Sacconi ran into these issues with a previous CMOS camera solution. "The previous CMOS camera we used had a small sensor and wasn't able to acquire the entire heart, so we decided to switch," he explains.

With a large FOV, more data can be captured with every acquisition, increasing throughput and simplifying experiments. In addition, high speed is a critical complement to the axially scanned light sheet, which requires a camera with a fast-rolling shutter. By synchronizing these mechanisms, light sheet images can be acquired optimally across large samples.

Furthermore, high resolution and high sensitivity are also beneficial, enabling suitable imaging quality for such a large sample.

Solution

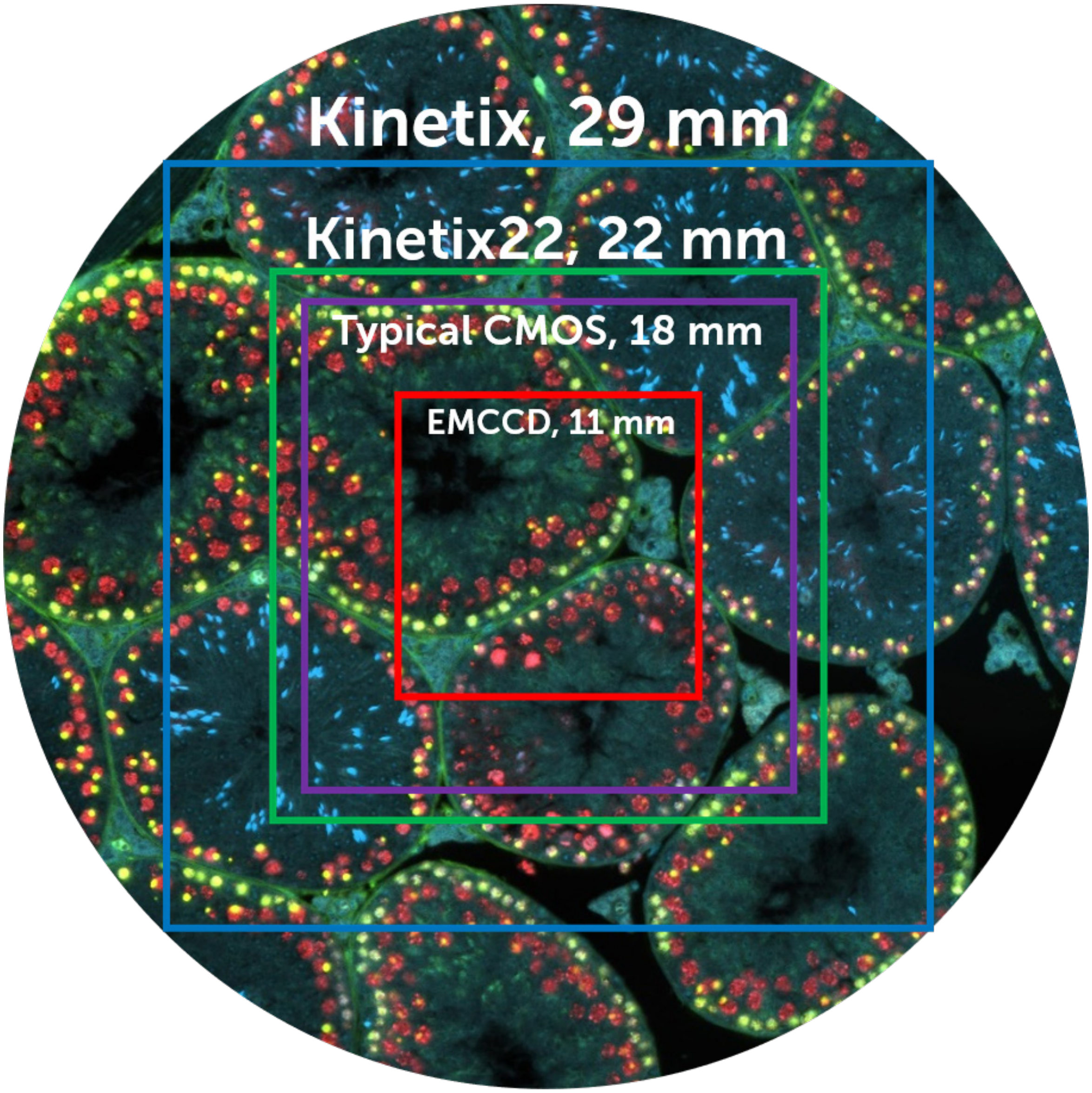
The Kinetix sCMOS camera meets the needs of this application, featuring a huge 29.4 mm FOV with a 10 megapixel sensor (3200 x 3200) and square 6.5 µm pixels. This allows imaging across a large area at high resolution, ideal for the large sample size.

The combination of the Kinetix camera and a 2x custom telecentric lens results in a FOV on the order of 1-2 cm, allowing the entire clear mouse heart to be captured in just one acquisition. As Dr. Sacconi notes, "The difference in cameras was amazing… the flatness of the field is most impressive, and the high frame rate is also important. This will be an interesting feature for future work."

Overall, the Kinetix camera is a great solution for large FOV light sheet applications, given its ability to image across a wide area with high resolution, high speed, and high sensitivity.

Kinetix Family: Field Of View

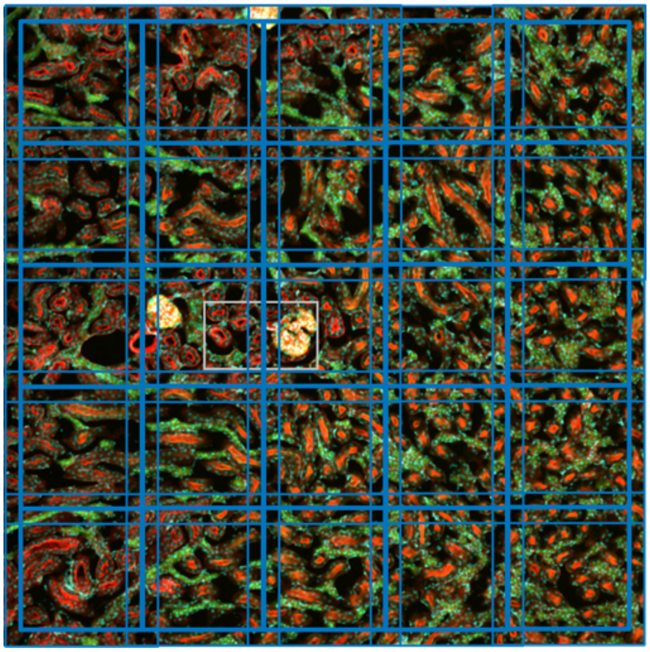
Large Sensors, High Throughput

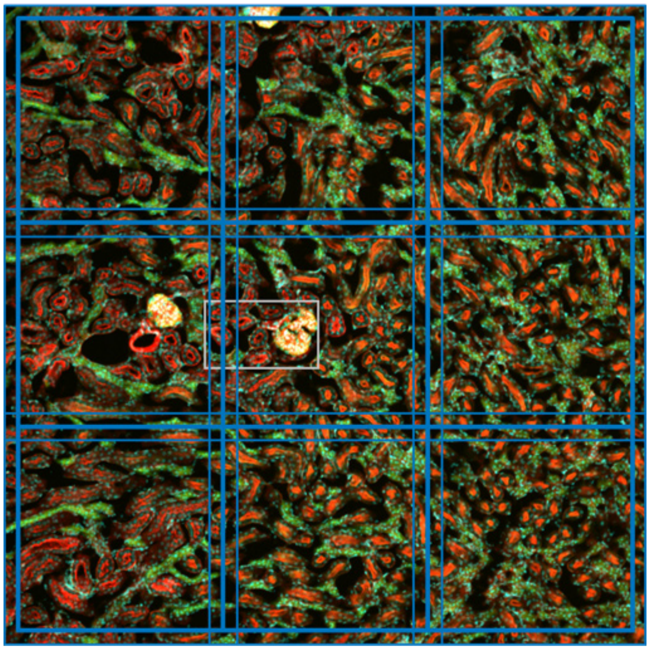


Kinetix Gives You More

Both Kinetix cameras feature large fields of view in order to capture more of your sample(s) with every acquisition, avoid excessive stitching/tiling, and enable efficient capture of large samples.

EMCCD and typical CMOS technologies generally rely on smaller sensors due to compromises in design, and often fail to capture all the information presented by the microscope. With the Kinetix Family, data capture can be maximized. Now there's no need to compromise!





Typical CMOS

Requires 25 separate acquisitions to fully image this large sample.

With stage movements, overlap, multichannels, and exposure, this means imaging takes a long time.

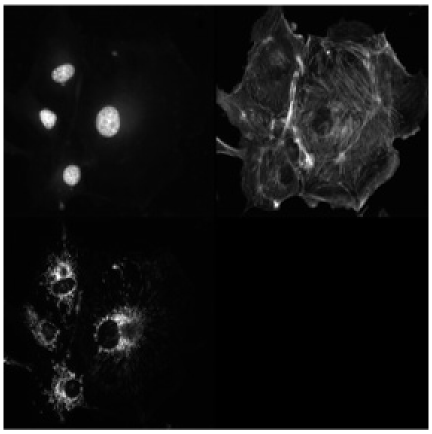
Kinetix

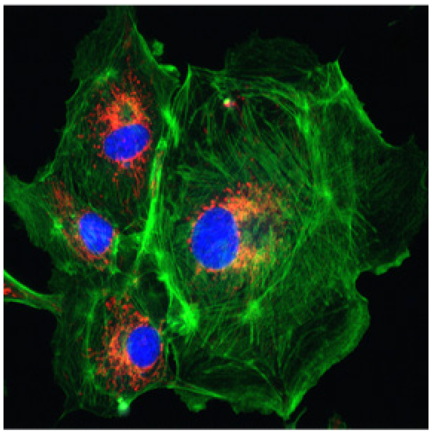
Only 9 acquisitions needed due to the sensor's 2.5x Kinetix sensor delivering a larger field of view.

This experiment is now 3x faster, effectively streamlining your science.

Image Splitters

Thanks to the large FOV of the Kinetix and Kinetix22, these cameras can be paired with image emission splitters, allowing separate parts of the sensor to detect different wavelengths for simultaneous multichannel imaging.





Kinetix Family: Speed

Customer Story: Prof. Xue Han and Dr. Eric Lowet

“We were able to record basically full field at 500 Hz and see single spikes with good signal to noise, which is very, very promising. The [Kinetix] was the first camera that was able to do this.”

Prof. Xue Han and Dr. Eric Lowet
Biomedical Engineering Department, Boston University

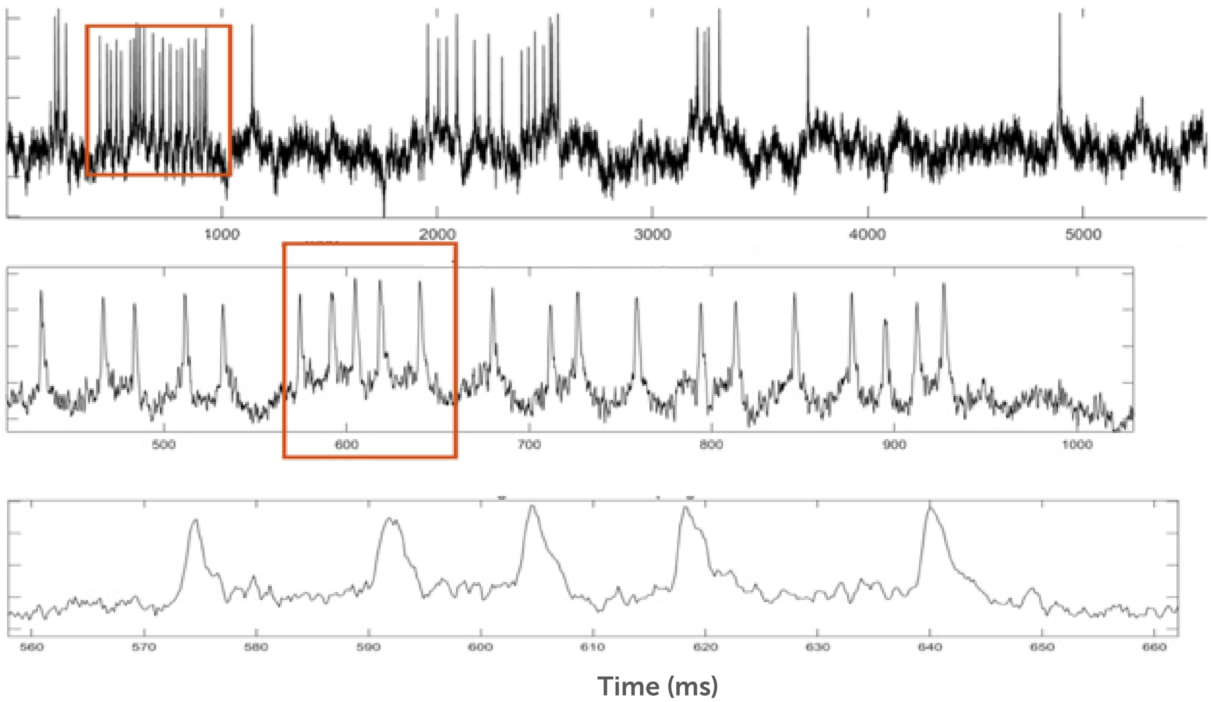


Figure 1: Kinetix voltage imaging data, from the Han Lab. Visual cortex neurons L1/2 were imaged at 5000 fps using the Kinetix 8-bit Speed mode. From top to bottom each graph zooms in on spike trains (orange box)

Background

The Han Lab focuses on inventing novel neurotechnologies and applying innovative approaches to probe the cellular and network mechanisms of brain disorders and brain stimulation therapies. Having a key role in the development of voltage probes (such as SomaArchon), the Han Lab frequently uses voltage imaging to capture high speed neuronal communication.

Challenge

Neuronal signaling, both action potentials and sub-threshold signaling, occur on the millisecond timescale and require a camera to be operating at 1000 fps (1 kHz) or faster. When imaging at such a high speed, exposure times need to be very short, meaning there is little time to gather signal. Fluorescent signals are typically very low, so sensitivity is also vital.

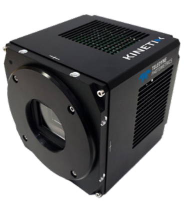
In addition, neurons are highly social cells and communicate in networks; the more cells that can be imaged at once, the more biologically relevant the information. This means that a large FOV is a big advantage, as it can support functional voltage imaging across a whole network.

Solution

Kinetix cameras meet all the needs of voltage imaging by imaging at a high speed across a large sensor with high sensitivity. Network imaging can be done at 500 fps across the full 29 mm sensor, or smaller clusters of cells can be imaged at several thousands of fps. Combined with low noise and high image quality, Kinetix is an ideal solution for voltage imaging.

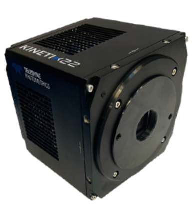
Kinetix Speed Tables (FPS over PCIe)

KINETIX



Array Size	Speed	Sensitivity	Dynamic Range	Sub-Electron
3200 x 3200	498	88	83	5
3200 x 1600	996	176	166	10
3200 x 800	1992	352	332	20

KINETIX22



Array Size	Speed	Sensitivity	Dynamic Range	Sub-Electron
2400 x 2400	498	88	83	5
2400 x 1200	996	176	166	10
2400 x 600	1992	352	332	20

TELEDYNE IMAGING
Everywhereyoulook™

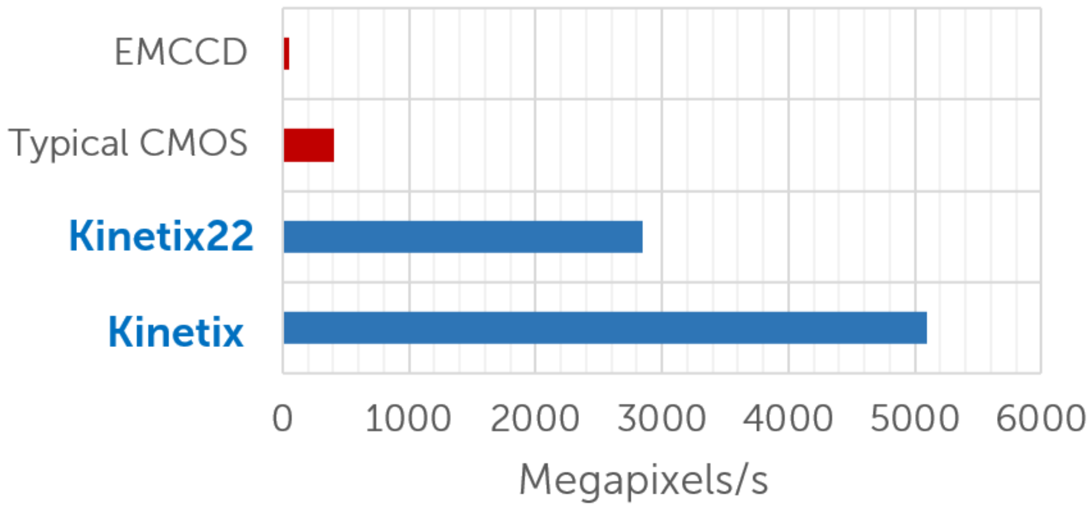
Kinetix Family: Speed

See What You Were Missing

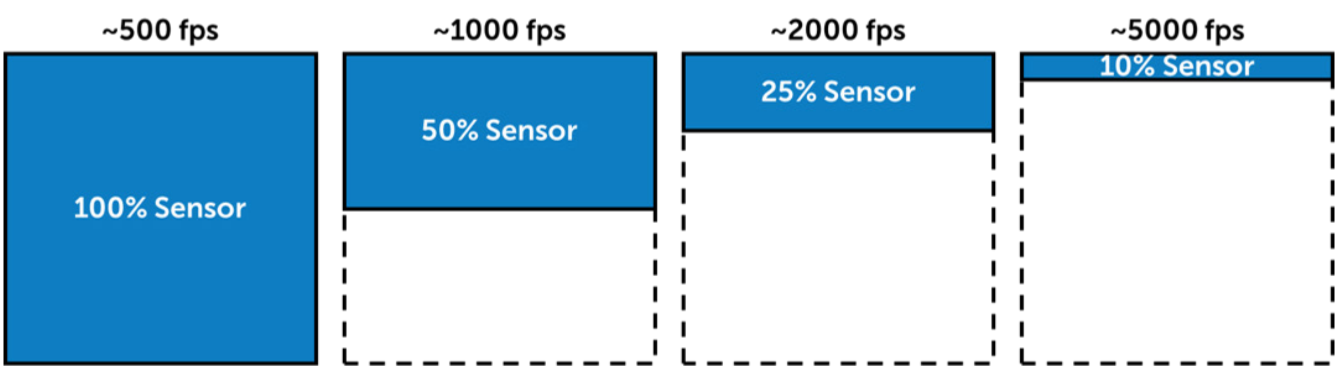
Kinetix Gives You More

Both Kinetix cameras feature extreme imaging speeds across the full sensor to capture dynamic samples with ease. Simply put, now you can image high speed events like you never could before.

While typical CMOS technologies can image at ~100 fps, the Kinetix Family can image at ~500 fps across a much larger frame by leveraging their faster speeds and greater data ratesrates, resulting in a huge difference in the acquired megapixels per second.



Thanks to the benefits of sCMOS technology, cropping the sensor increases the speed. Kinetix cameras run at ~500 fps full frame, which is doubled for a half-sensor region, and so on. This enables the cameras to run at extremely high speeds for low row numbers, while retaining the full width. The actual region of interest can be placed anywhere on the sensor around your samples.

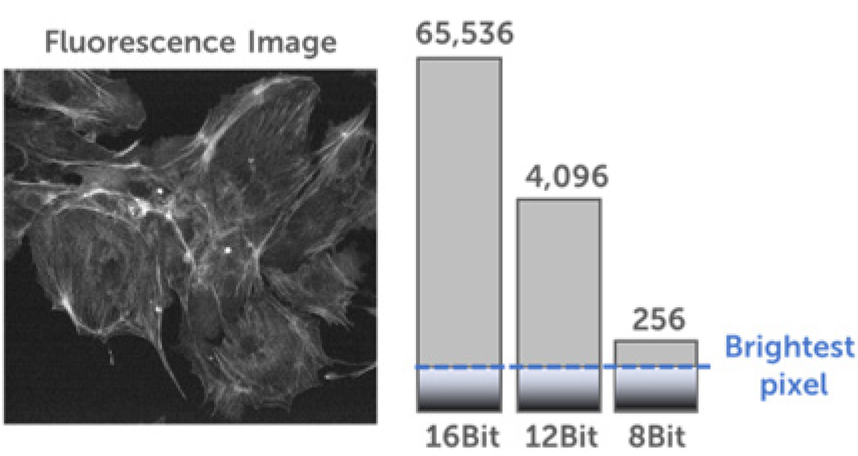


Kinetix Speed Mode

The Kinetix Family is at its absolute fastest (~500 fps full frame) when operating in speed mode with PCIe digital interfaces. This 8-bit speed mode features an extremely fast line time. While typical scientific cameras operate at 12 bits or 16 bits, our 8-bit mode offers tremendous advantages for fluorescence imaging applications that crave real speed:

- 8-Bit Mode Is Faster
- 8-Bit Halves Data Size
- 8-Bit Matches Your Signal Level
- Our 8-Bit Mode Is Optimized For Quantitative Imaging
- 8-Bit Mode Allows For Flexibility

Fluorescence imaging is typically characterized by low signal levels (especially with high speeds reducing exposure times), meaning that our 8-bit speed mode is well suited to this quantitative imaging format, both in terms of data rate and signal level.



Kinetix With A PC

Due to the ground-breaking data rates provided by the Kinetix family, it is vital to pair each of these cameras with a suitable PC when planning high speed imaging across the entire large sensor. While Teledyne Photometrics cameras generally work on any hardware that supports the interface and PVCAM installation, there are a few extra components to consider:

- OS: Windows 10 64-bit
- CPU: ≥4 cores, ≥3 GHz
- 32 GB DDR4 or better
- Storage: ≥ 256 GB SSD
- USB: 3.1 G2 or better
- PCIe: available x8 or x16 slot

Kinetix Family: Sensitivity

Customer Story: Dr. Marco Polin

> “We needed a very sensitive camera like the Kinetix to record changes in fluorescence and measure intensity.”

Dr. Marco Polin
Mediterranean Institute for Advanced Studies (IMEDEA), University of the Balearic Islands

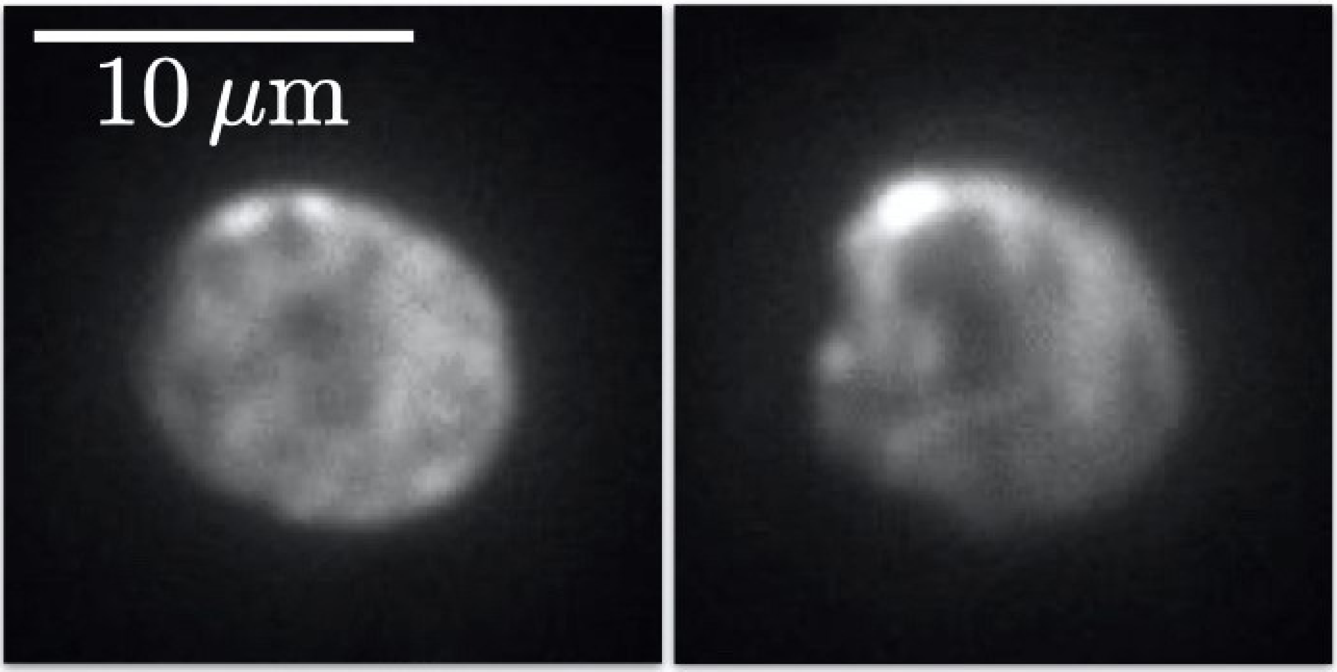


Figure 1: Changes in autofluorescence of a single C. reinhardtii chloroplast, taken with a Kinetix sCMOS camera. High sensitivity is needed to detect minute fluctuations in fluorescent signal.

Background

Dr. Polin researches the motility and behavioral responses of the microalgae Chlamydomonas reinhardtii, used as a model system for studying eukaryotic flagella, photosynthesis, and phototaxis. These microorganisms detect and react to light, orienting themselves towards or away from light sources. The small samples are studied through chlorophyll autofluorescence by observing light induced changes in behavior. Studying this phototaxis has potential use in bioreactors.

Challenge

Changes in microalgae metabolism are investigated by imaging the minute changes in chlorophyll autofluorescence, requiring a highly sensitive camera with low noise levels to study these organisms over time.

As these samples react to light, it is vital to be able to control the illumination for stimulating the microalgae, as well as to be able to detect the small autofluorescent signals from each single cell. With a highly sensitive camera, lower illumination can still be detected, allowing researchers to avoid bleaching/photodamage of their samples.

Solution

The Kinetix sCMOS camera is a highly sensitive imaging solution, suitable for low light applications that require fine levels of signal quantification for delicate samples. Imaging of small, photosensitive samples is well suited to the Kinetix camera's sensitivity mode, which features near-perfect 95% QE to maximize signal collection as well as CMS technology to minimize the effect of read noise.

With its new sub-electron mode, Kinetix achieves read noise levels of 0.7 electrons, allowing highly sensitive imaging of even very weak signals.

Dr. Polin characterized his experience with the Kinetix in the following way. "The camera works well. We can measure fluorescence, and in the range of parameters we are aiming to work in, the camera is responding very well. [It's] a very nice device... the high resolution of the Kinetix works really well and the setup was straightforward."

Kinetix Family: Sensitivity

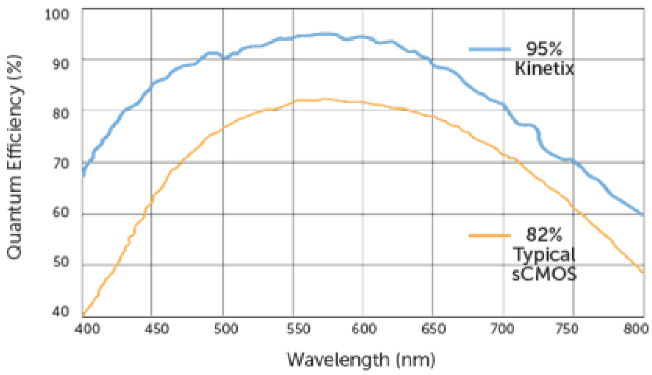
Detecting Even The Weakest Signals

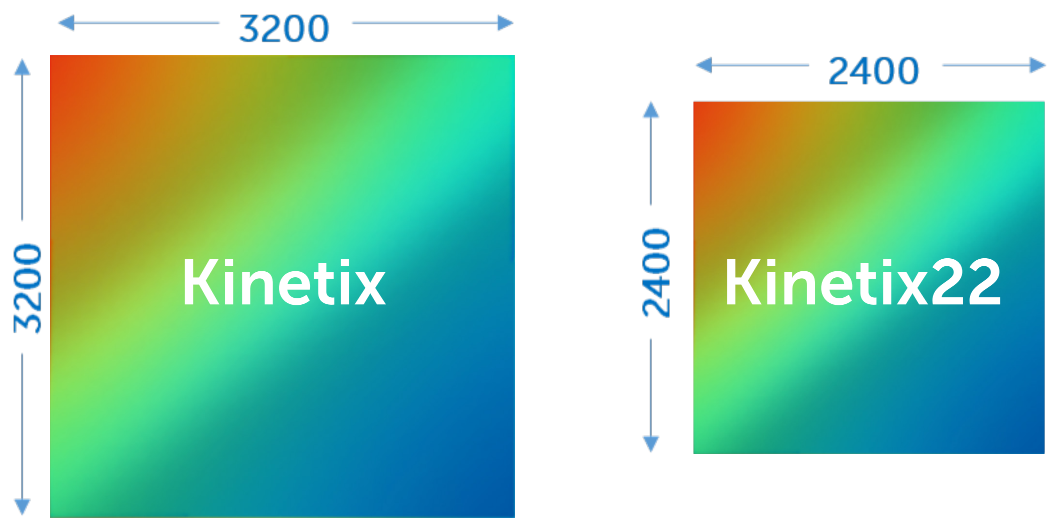
Maximizing Signal Collection

Kinetix and Kinetix22 are back-illuminated sCMOS cameras pioneered by Teledyne Photometrics that deliver near-perfect 95% quantum efficiency (QE) at peak, as well as high sensitivity across a wide range of wavelengths, from infrared to ultraviolet.

As shown in the QE curve, Kinetix QE is especially high at visible wavelengths, which are commonly used for fluorescence imaging in the life sciences.

The Kinetix family uses square 6.5 μm pixels that are large enough to capture signal from the sample and small enough to promote resolution at a variety of magnifications.

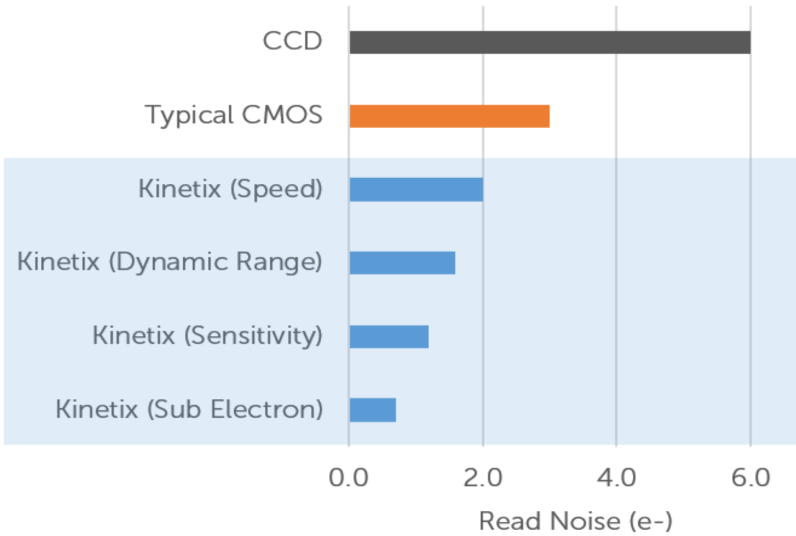




Minimizing Noise

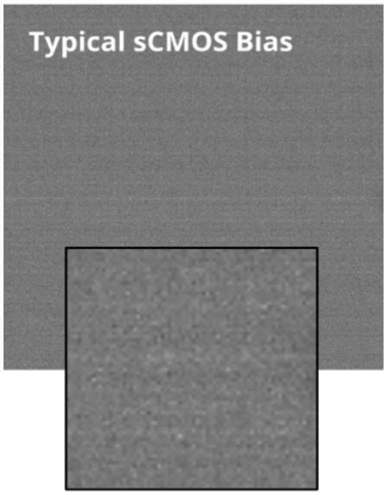
Noise is an error in measurement that exists in all cameras, but by implementing elegant electronic design the sources of noise can be minimized to permit detection of ultra-low-level signals.

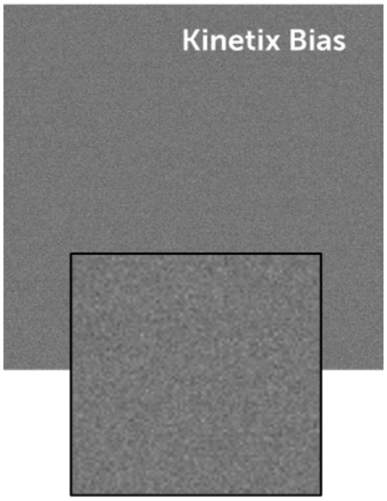
All Kinetix family modes offer remarkably low read noise, especially sub-electron mode, which achieves noise levels akin to EMCCDs.



Another source of noise (often ignored in datasheets) is the presence of patterns and artefacts on the camera sensor, such as column noise, hot pixels, or non-uniformity.

The Kinetix family, however, offers both superior background quality and scientific image quality. Our pattern and correlated noise reduction technology delivers clean, pattern-free images, helping to minimize noise levels in low light conditions.





Kinetix Family: Sensitivity

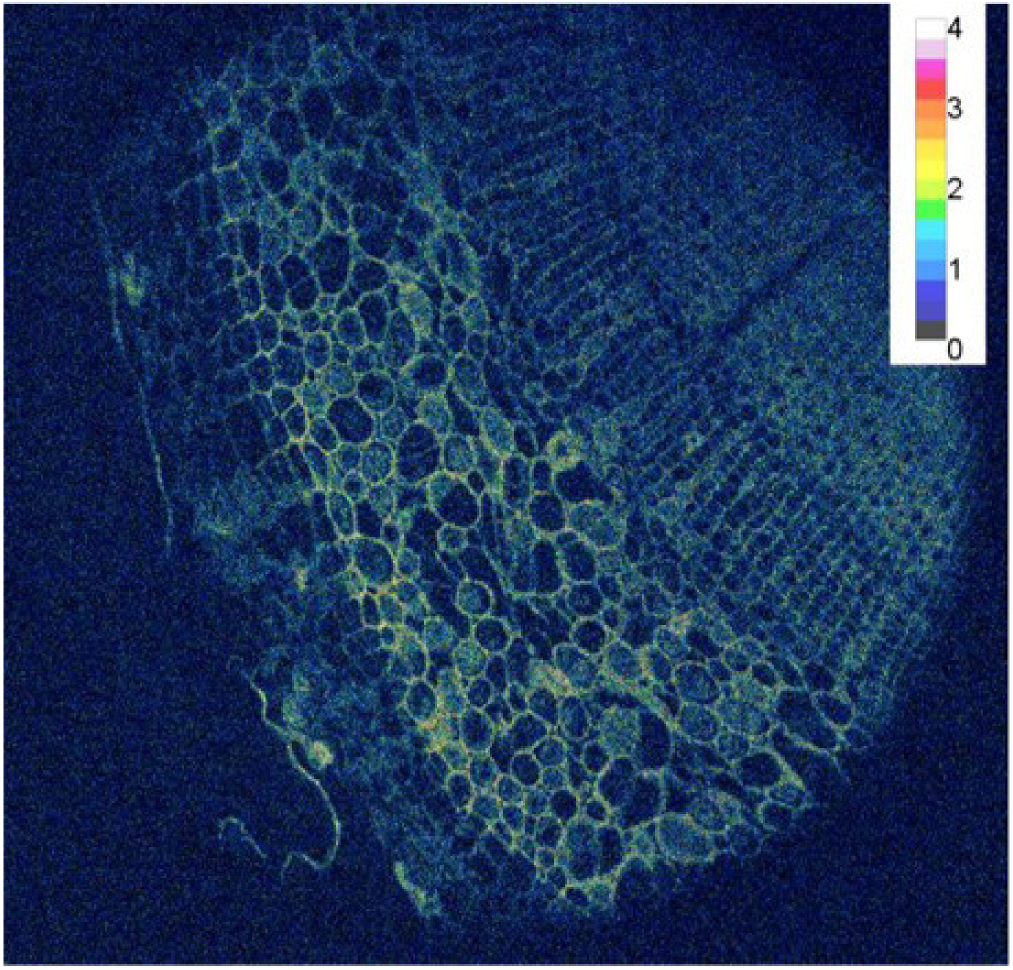
Sub-Electron Mode

Ultimate Sensitivity

The sub-electron mode used by the Kinetix family employs two distinct strategies to generate read noise akin to EMCCD sensors while avoiding classic EMCCD complications such as excess noise factor and EM gain decay.

Firstly, Sub-Electron mode measures the internal signal from each pixel multiple times to reduce measurement errors. Secondly, the conversion gain is set to a highly sensitive value so that low signal changes are spread across a wider range of gray levels. The net result is low noise, high contrast performance exceptionally well suited for high precision measurements at low total signal intensity.

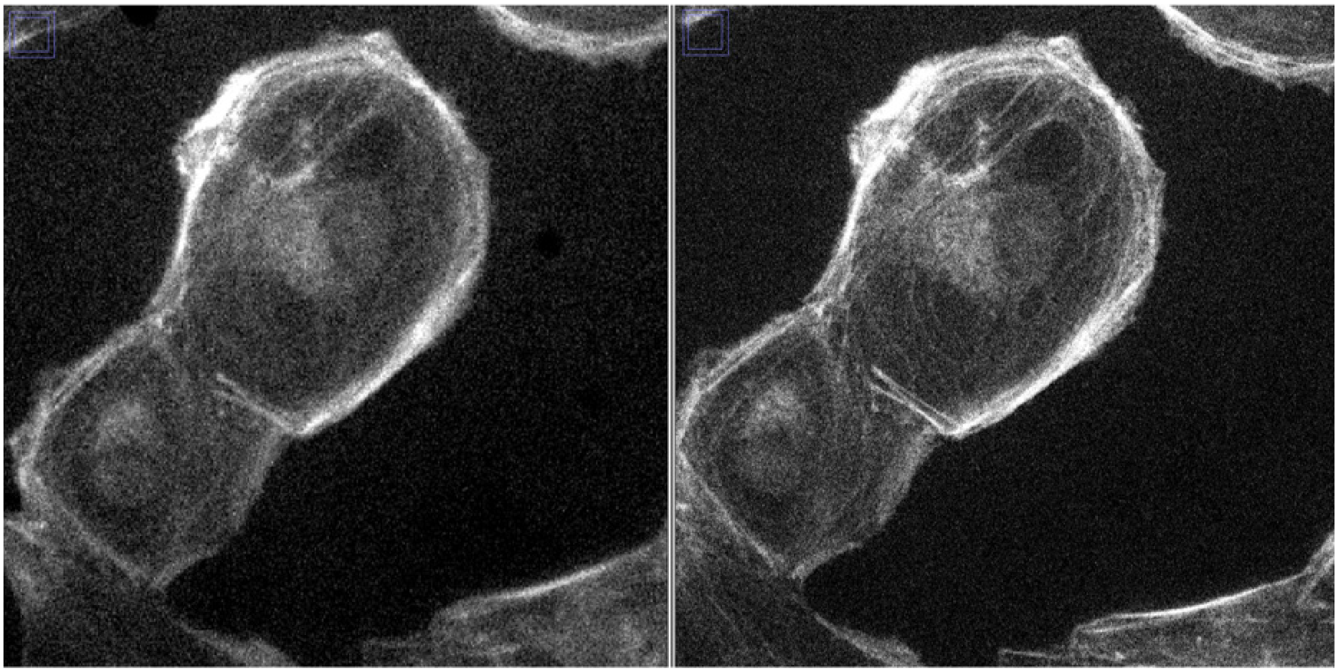
This image shows a plant root captured with a Kinetix camera in sub-electron mode using only a 100 µsec exposure. Structured signal levels from 1 to 3 e^- (see scalebar) are easily visualized thanks to the low read noise and digital conversion gain, which avoids enforcing quantization to single electron values.



TELEDYNE IMAGING
Everywhereyoulook™

Kinetix vs EMCCD

Owing to the smaller pixels of the Kinetix family's sCMOS sensor and the low noise inherent in Sub-Electron mode, researchers can resolve structures lost to the larger pixels and higher signal noise typical of EMCCD cameras while still capturing a much larger FOV. Here we demonstrate the difference between a Sub-Electron mode Kinetix sCMOS camera and a typical EMCCD on the same sample, at the same signal level.



The two images show the phalloidin-stained actin cytoskeleton of a CV-1 cell, which were acquired using a typical EMCCD camera (left) and a Sub-Electron mode Kinetix sCMOS camera (right). Exposure time is identical and pixel sizes are matched for easier side-by-side comparison. Sub-electron mode enables EMCCD levels of read noise while retaining all the advantages of sCMOS.

Important to note is that these two images are cropped for comparison, thanks to the larger sensor of the Kinetix, you get this ultra low-noise performance while also imaging ~7x more of your sample per acquisition, compared to typical EMCCDs.

This level of performance is only achievable with Kinetix.

Kinetix Family: Advanced Features

Offering Optimised And Powerful Solutions

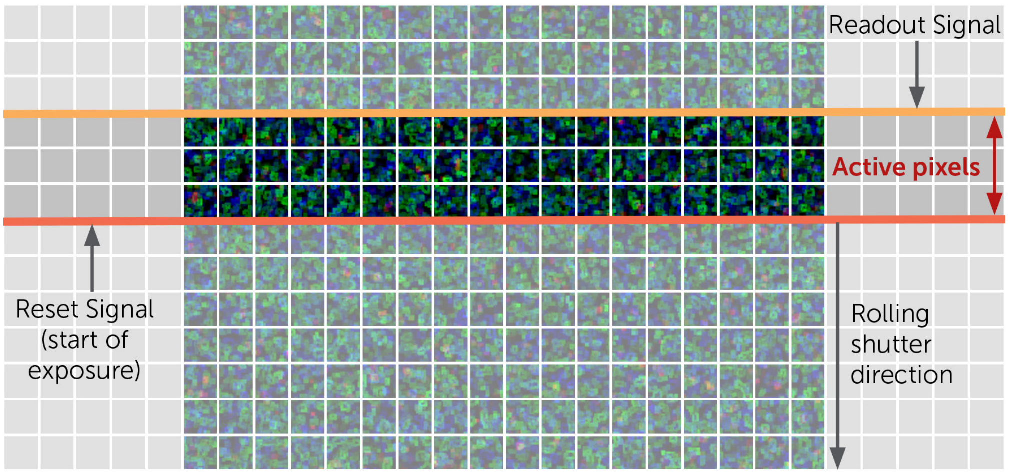
Programmable Scan Mode

Controlling CMOS Imaging

Introduction

Applications such as light sheet microscopy and spinning disk confocal microscopy often use rolling shutter readout of CMOS sensors to enhance image quality. Programmable Scan Mode (PSM) allows additional control over the rolling shutter and readout, for example, adding delays to groups of rows and changing the readout direction. PSM is an advanced feature found in our Kinetix family of cameras.

For rolling shutter CMOS, a reset signal starts exposure in the top row and sweeps down to the bottom row. It is followed by a readout signal that starts digitizing (reading out) each row and sweeps down. The time between the reset and readout signals is defined as the exposure time. Rolling shutter readouts typically digitize one row of pixels at a time, at a rate referred to as the line time.



With PSM, these factors can be modified to control the timing and direction of the scan.

Scan Timing

PSM has three main settings in imaging software for altering scan timing, this is useful for establishing synchronization between illumination and acquisition.

1. Auto: The default option. The line time is set to one line, preventing the user from setting a delay between the reset and readout signals.
2. Line Delay: Adds a delay after the line time, slowing the reset and readout signals, and increasing the effective line time.
3. Scan Width: Allows the user to set the number of rows between the reset and readout signals, specifying the number of rows in the detection region.

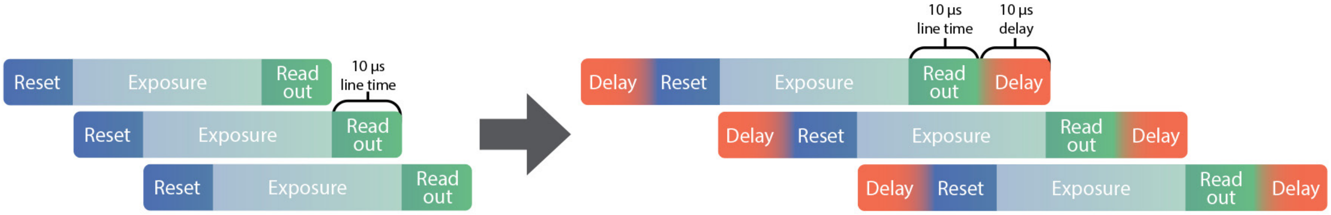
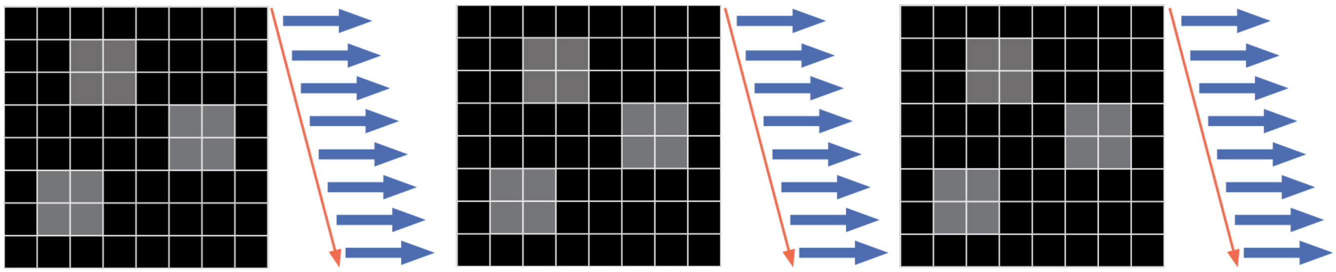


Figure 1: CMS x2 for the Kinetix sensitivity mode. The graph shows voltage over time for a single pixel. Two simultaneous measurements of the rest voltage (blue arrows) and total voltage (green arrows) are taken.

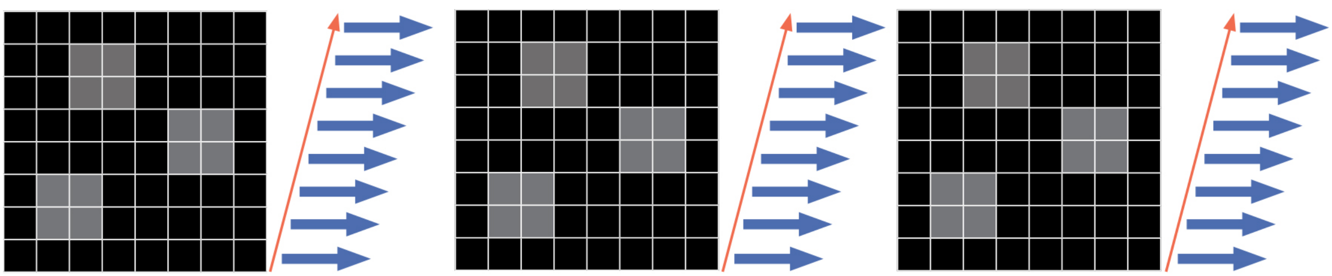
Scan Direction

PSM also provides three main settings in imaging software for altering the scan direction. This is useful for matching up the physical camera orientation within advanced imaging systems, or scanning/strobing light sources.

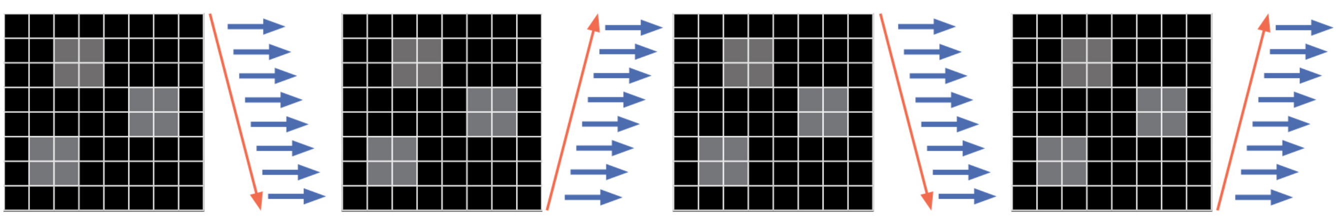
1. Down: The default option. The rolling shutter starts at the top row of the sensor and propagates down to the bottom row. Each new frame then starts again at the top row.



2. Up: Inverts the direction of readout, which starts at the bottom and propagates up to the top row. Each new frame then starts at the bottom row. Images acquired in this mode are not inverted and are the same as with 'Down' mode.



3. Down-Up Alternate: With this mode, the direction of readout alternates between frames. The rolling shutter first travels top to bottom, and for the next frame it travels bottom to top. The image orientation when acquired in this mode will have no inverted frames and will be consistent with the Down scan direction.



Summary

Programmable Scan Mode is exclusive to Teledyne Photometrics and allows unprecedented control over CMOS readout scanning, including timing, width, and direction. PSM is often used with light sheet/spinning disk, strobing light sources, and/or when exposure time needs to be carefully controlled. Overall, PSM can advance your imaging through fine camera control.

TELEDYNE IMAGING
Everywhereyoulook™

Minimizing Noise

CMS for Sensitivity and Sub-Electron Read Noise

Introduction

sCMOS cameras feature a readout circuit for every column, which has historically led to pattern noise. Pattern noise, along with random noise sources such as read noise, is especially problematic when imaging at low signal levels. A successful scientific camera needs to minimize noise sources in order to image quantitatively in low light conditions.

At Teledyne Photometrics, we pride ourselves on minimizing camera noise so that you get the quality measurements needed for your science. This section will outline our methods for minimizing both read and pattern noise.

Minimizing Read Noise

The Kinetix uses correlated multi sampling (CMS) in order to minimize read noise, which involves measuring the internal signal from a pixel multiple times, which reduces measurement error (read noise) at the cost of speed. The resting voltage and total voltage across each pixel is measured, the difference between them being the actual signal. In CMS mode, these voltage measurements can be repeated any number of times.

For 12-bit Sensitivity mode, the Kinetix does two simultaneous pixel voltage reads using the dual readout circuits (which are also used to generate the 16-bit dynamic range mode), as seen in Fig.1.

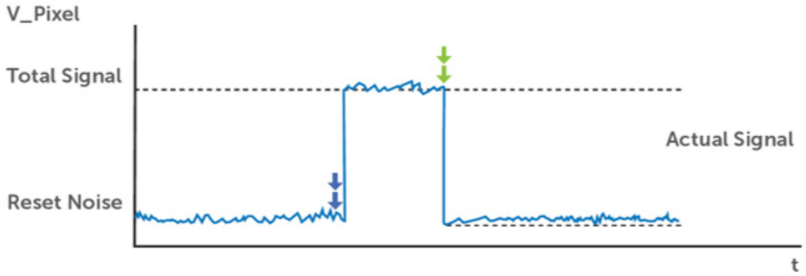


Figure 1: CMS x2 for the Kinetix sensitivity mode. The graph shows voltage over time for a single pixel. Two simultaneous measurements of the rest voltage (blue arrows) and total voltage (green arrows) are taken.

In 16-bit Sub-Electron mode, Kinetix performs eight sequential pixel voltage reads, see Fig.2. This results in extremely low read noise (~0.7 e-, akin to EMCCD technologies) but with a sharp decrease in camera speed.

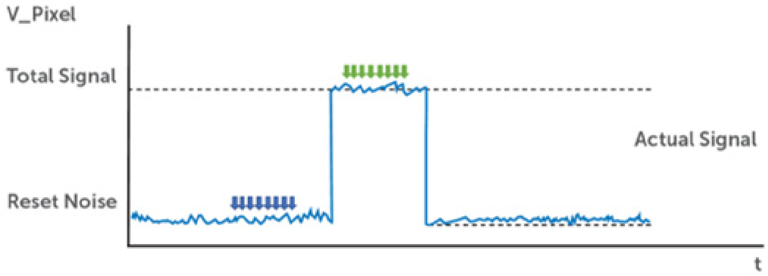


Figure 2: CMS x8 for the Kinetix sub-electron mode. The graph shows voltage over time for a single pixel. Eight sequential measurements of the rest voltage (blue arrows) and total voltage (green arrows) are taken.

Speed and Sensitivity

A low noise mode is a popular feature for scientific CMOS cameras due to the impact of noise on imaging experiments, but these implementations usually reduce the camera speed to levels where acquisition is negatively affected. Typical CMOS cameras operating in a low read noise mode often run at ~20 fps, even if they can read ~100 fps in other modes. With Kinetix, however, there is no need to compromise.

The 2048 x 2048 Kinetix runs in sensitivity mode with CMS at ~140 fps, around seven times faster than typical CMOS sensors of the same size. The 3200 x 3200 Kinetix (~2.5x larger than typical CMOS sensors) runs at ~90 fps, still far faster but with a much larger FOV.

This means that with Kinetix you don't have to choose between sensitivity and speed. The sensitivity mode offers low read noise (~1.2 e^-) with CMS mode while retaining high speed for dynamic imaging.

Kinetix Sub-Electron Mode

Because Kinetix read noise is less than a single electron in this mode, detecting extremely faint signals is achievable. The analog signal in the camera, measured in electrons, is converted to digital gray levels in software (controlled by the gain) in order to provide high image contrast at low signals. The saturation level for sub-electron mode is ~1000 electrons at 16 bits, resulting in a gain of 2^16 / 1000, or about 0.015 e-/gray value.

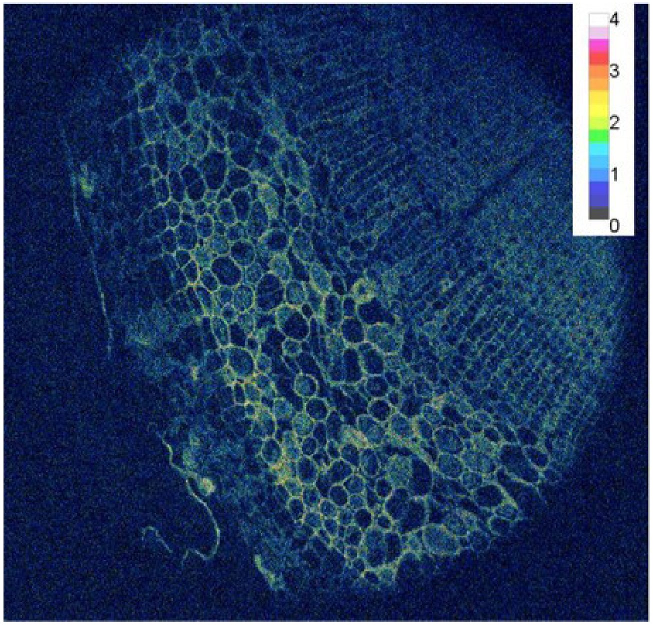


Figure 3: Kinetix image of plant sample in sub-electron mode. Scale bar in electrons shows that signal differences of just a single electron can be clearly differentiated.

Using this mode, 1 electron of signal results in 50-67 gray levels; the precise value is detailed on the Certificate of Performance provided with every individual camera. This range of values rivals the potential performance of EMCCD cameras -- but does not suffer from the extra noise factor that EMCCDs amplification p rocess introduces.

Figure 3 shows the benefits of sub-electron mode at very low signal levels. The reduction of read noise allows highly sensitive imaging.

In this manner, Kinetix minimizes read noise, which can positively impact imaging in several ways. Firstly, it enables better imaging of samples that have a very low signal. Secondly, it allows the illumination intensity and/or exposure time to be significantly reduced for typical samples whilst retaining image quality. This capability permits longer experiments and less bleaching/photodamage.

Minimizing Noise

CMS for Sensitivity and Sub-Electron Read Noise

Minimizing Pattern Noise

Unlike read noise, which affects image quality for all scientific cameras, pattern noise is primarily an issue for CMOS-based imaging devices. Pattern noise is often most noticeable on older CMOS cameras as column noise, which is attributable to the amplifiers present in each column as well as to the combination of both column-to-column variation and pixel-to-pixel variation. For this reason, pattern noise is an understandable concern for researchers who plan to use sCMOS cameras for quantitative imaging. See Figure 4.

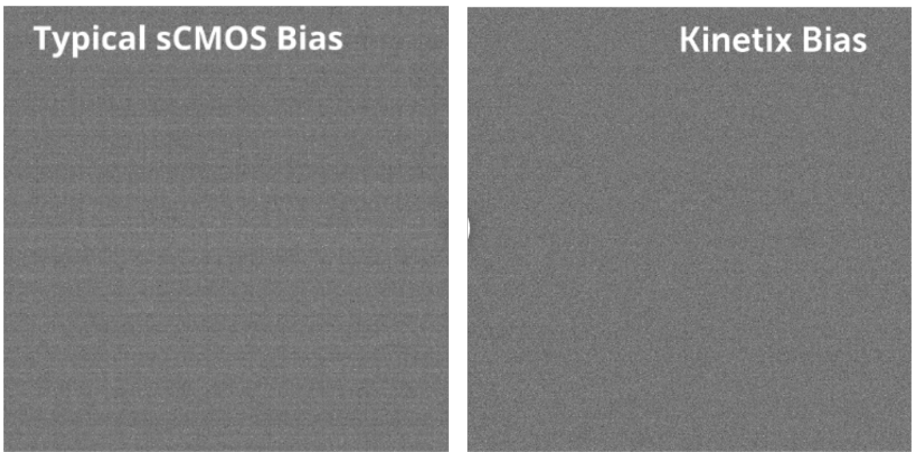


Figure 4: Comparing the patterning on a typical CMOS device and Kinetix. Some typical CMOS devices used split sensors to increase camera speed, but this results in vertical and horizontal banding patterns. Kinetix uses a single sensor and careful design to eliminate patterns and artefacts.

FeaturesAt low signals, issues like pattern noise or irregular illumination flatness can interfere with good detection and subsequent analysis. Figure 5 shows microbeads imaged under low light conditions, generating 0-10 e- of signal. The microbeads were imaged by a Kinetix camera running in sub-electron mode and the results were then analyzed.

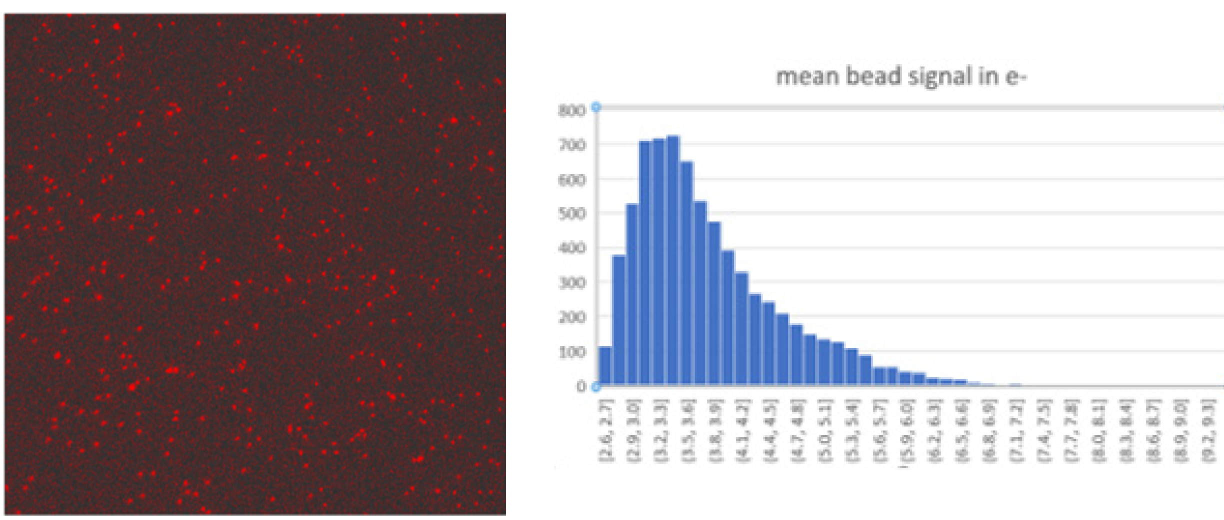


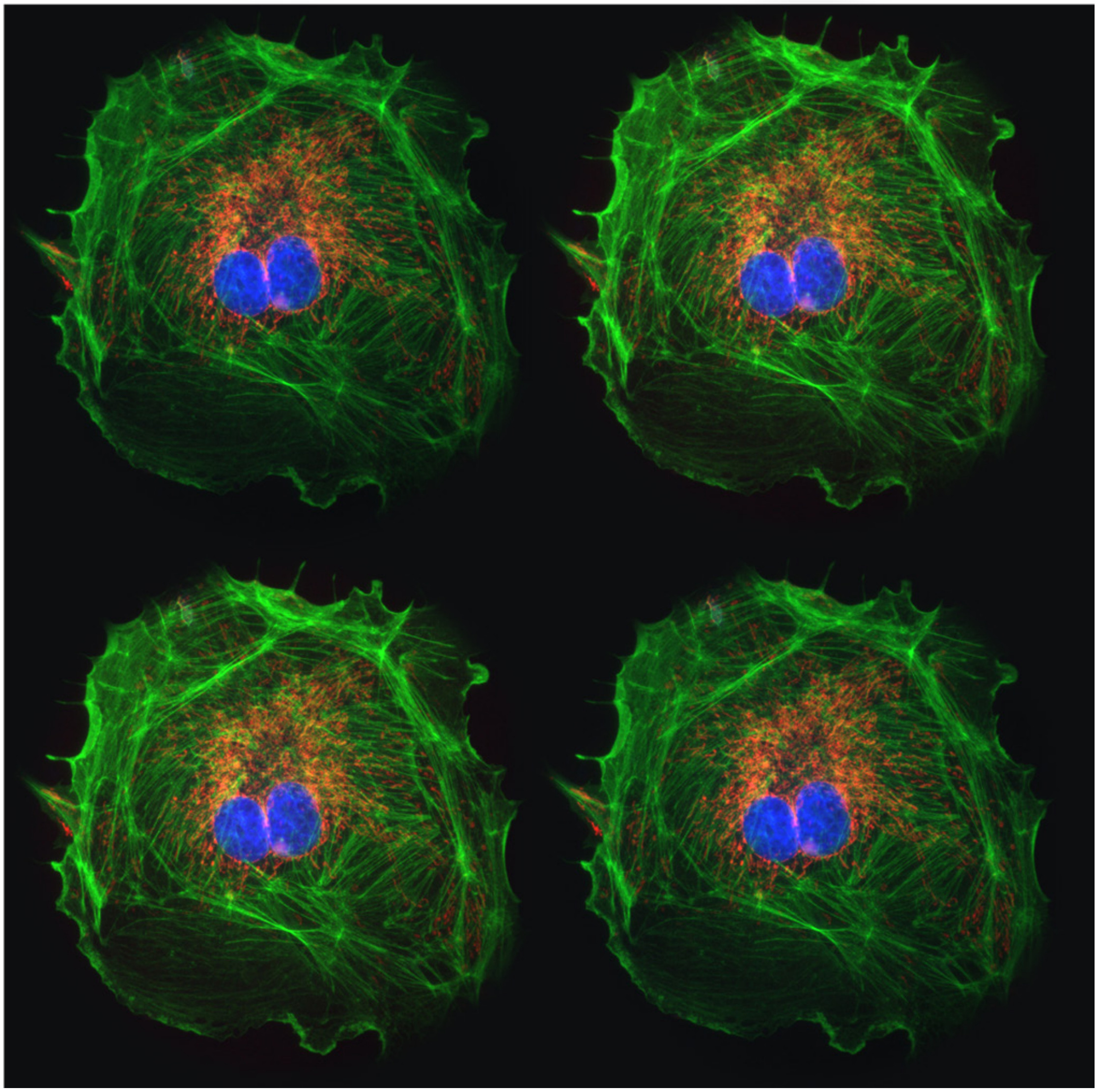
Figure 5: Comparing the patterning on a typical CMOS device and the Kinetix. Some typical CMOS devices used split sensors to increase camera speed, but this resulted in vertical and horizontal banding patterns. The Kinetix uses a single sensor and careful design to eliminate patterns and artifacts.

TELEDYNE IMAGING
Everywhereyoulook™

Minimal Noise Leads To Maximum Sensitivity

Thanks to CMS mode minimizing read noise and Teledyne Photometrics' elegant electronic design removing pattern noise, the Kinetix family is an ideal solution for applications that require high sensitivity, such as imaging with high speed, low light, and/or short exposures.

All four modes of the Kinetix family (Speed, Sensitivity, Sub-Electron, Dynamic Range) feature low noise performance. The figure below presents each Kinetix mode at 75% full well capacity and the resulting image quality.



Linescan

Delivering Extreme Speeds

Introduction

With CMOS cameras, reducing the number of sensor rows proportionally increases the speed. This means that extreme speeds can be attained when imaging low numbers of rows. Such speeds may be needed to measure highly dynamic processes, to increase speeds in slit scan confocal or light sheet systems, or to measure the distribution of signal from the output of a spectrograph.

No matter your requirements, the Kinetix family can take a limited number of full-width rows and read them out at high speeds, achieving frame rates comparable to highly specialized linescan cameras that simply sample along a single line. With the Kinetix family, you can use this linescan mode for one experiment, and then go back to the full sensor and scan the entire field of view of your sample in your next experiment.

Speeds At Low Row Numbers

When a Kinetix camera is 'regioned down' to a very small number of rows (less than 100), the reduction in 'frame' rates of these limited regions doesn't exhibit a linear relationship in respect to the frame rates of the full sensor. Bearing this in mind, we've measured these speeds with the Kinetix camera and provided the table below to help you know what to expect when imaging a very small number of rows.

Line Scan ROI Frame Rates in kHz				
Array Size	Dynamic Range	Speed	Sensitivity (CMS)	Sub-Electron
3200 x 64	4.1	21.1	4.3	0.2
3200 x 32	8.1	36.4	8.3	0.5
3200 x 16	15.7	57.1	15.7	0.8
3200 x 8	29.6	80.0	28.3	1.4
3200 x 4	53.3	99.4	47.2	2.1
3200 x 2	88.9	107.2	47.2	2.7

Kinetix speeds at small row numbers. Speed values are in kilohertz, where 1 kHz is 1000 fps. Based on measurements using PCIe interface on a Kinetix having firmware 30.32.1.

The linescan format results in smear-free imaging of fast moving samples, highly efficient image processing, and allows the Kinetix to be used in an even wider range of applications. Kinetix cameras can operate at such high speeds (>100,000 fps) in linescan formats that they can be used for applications beyond the realm of typical area scan sCMOS cameras, such as fluorescence correlation spectroscopy and machine vision.

Triggering

Pairing Camera With Light Source

Introduction

Triggering allows additional hardware control over the electronic shutter of the Kinetix family. In order to specifically determine when a camera produces an image, as well as to control other factors such as exposure time, a trigger can be used to communicate with the camera.

At Teledyne Photometrics, we make use of advanced BNC hardware trigger cables, which permit control of up to four separate pieces of hardware and can be used to synchronize the camera with a light source.

Our advanced hardware triggering BNC cable.

Input or Output

Using triggering, Kinetix can be controlled with imaging hardware (input) or vice-versa (output):

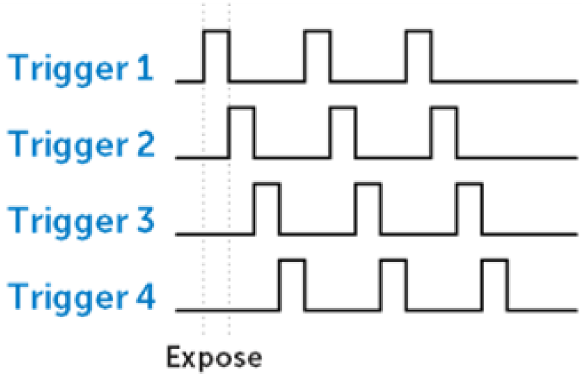
Input Modes: Internal, Trigger First, Edge, Level
Output Modes: First Row, All Rows, Rolling Shutter, Line Output, Any Row

These triggers control the initiation of imaging and can modify exposure time and frame overlap. For more information, see the Kinetix and Kinetix22 datasheets at the end of this document.

Multiple Triggers

The Kinetix family has four independent trigger output signals, enabling the camera to exert hardware control over multichannel illumination, such as LED light sources, which can be cycled within each image frame, as shown below.

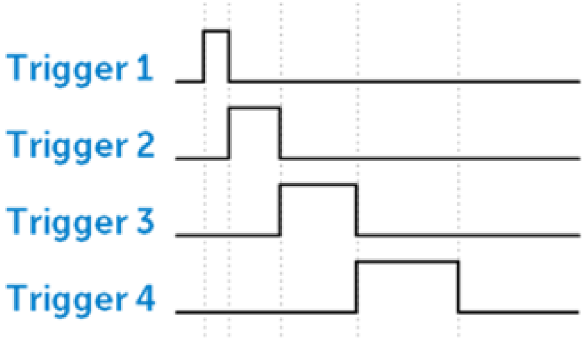
These independent trigger output signals are useful for fixed exposures. For variable exposure times we offer SMART Streaming.



SMART Streaming

Sequenced Multiple Acquisition Real-Time Streaming, or SMART Streaming, is an exclusive Teledyne Photometrics camera feature.

With SMART Streaming, the Kinetix family can capture a continuous sequence of images while cycling through a maximum of 16 pre-programmed exposure time values. This results in very high frame rate imaging that maintains the correct exposure level for each fluorophore.



TELEDYNE IMAGING
Everywhereyoulook™

Multi-Camera

Multiple Kinetix On One Card

Introduction

The Dolphin PXH832 PCIe card specified and supplied for use with the Kinetix family has multiple ports and can be configured for PCIe 4, 8, or 16 lane operation. This allows you to run as many as four Kinetix cameras (in some modes) via a single PCIe card without experiencing a reduction in frame rate.

Kinetix Multi-Camera Configuration

The maximum data rates (in fps) achievable for various camera number and mode combinations are presented in Table 1. We at Teledyne Photometrics highly recommend using an x16 PCIe card slot on the motherboard for multi-camera setups in order to achieve maximal data throughput.

Kinetix Multi-Camera Configuration

			Camera Speed (fps)		
Mode	**No. of Cameras**	**MB/sec**	**PCIe x4**	**PCIe x8**	**PCIe x16**
Dynamic Range	2	3242	83	83	83
	3	4863	67	83	83
	4	6484	41	83	83
Sensitivity	2	2637	89	89	89
	3	3955	89	89	89
	4	5273	67	89	89
Sub-Electron	2	213	5.2	5.2	5.2
	3	319	5.2	5.2	5.2
	4	426	5.2	5.2	5.2
Speed	2	9766	202	403	498

Table 1: Kinetix speeds for multiple cameras, in different modes, with various PCIe configurations. The combinations that deliver the maximum published frame rate for a given mode are highlighted in green.

PCIe DIP Switch Configurations

On delivery, the PCIe card is set to x8 mode, allowing control of one or two cameras in all operating modes, with DIP switches in the configuration shown in Figure 1. This allows operation of up to two cameras at x8 performance.

Figure 1

To configure the card for three or four cameras, it is necessary to change the DIP switches on the card to the configuration shown in Figure 2, which treats each connection as a single x4 port.

Figure 2

Cable Length

Adapting To Your Setup

Introduction

While Kinetix family cameras are supplied with a full range of cables and cards for the PCIe digital interface, we appreciate that every lab and scientific facility has a different layout and long optical cables are sometimes needed.

The PXH832 PCIe card that comes with the Kinetix family is compatible with active fiberoptic PCIe cables up to 100 meters in length. No special configuration of the card needs to be performed when working with long cable lengths, but maximum achievable speeds can be affected depending on the length of the cable. Maximum achievable frame rates (in frames per second) using long fiberoptic cables for three Kinetix modes are presented below. CWAKE and CPOWERON are not supported using standard AOC cables.

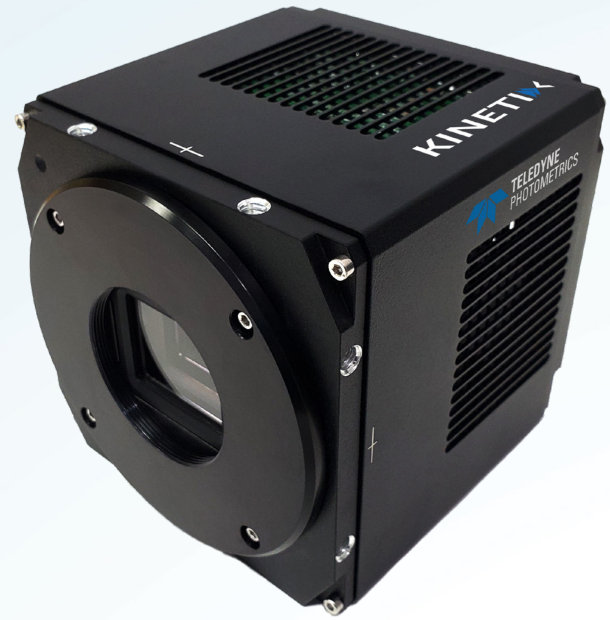
	1x PCI-E 16 Lane (default shipping configuration)		**2x PCI-E 8 Lane** (Configuration to run 2 cameras on 1 PCI-e Card. Tested with Single camera)	
	100m	**50m**	**100m**	**50m**
HDR-16-bit	83	83	83	83
Sensitivity-12-bit	88	88	88	88
Speed-8-bit	458	498	287	442

Note: Only PCIe fiberoptic cables from Dolphin are supported. Standard MiniSAS-HD AOC cables are not supported.

Kinetix Family: Datasheets

The New Category In sCMOS Cameras

TELEDYNE PHOTOMETRICS
Everywhereyoulook™



KINETIX

The New Category In sCMOS Cameras

10 Megapixel
6.5 µm Pixel Size
498 Frames Per Second
29.4 mm Field Of View
95% Quantum Efficiency

Specifications	Camera Performance
Sensor	Teledyne Photometrics Kinetix Sensor
Active Array Size	3200 x 3200 (10.24 Megapixel)
Pixel Area	6.5µm x 6.5µm (42.25µm²)
Sensor Area	20.8mm x 20.8mm 29.4mm diagonal
Peak QE%	>95%
Readout Mode	Rolling Shutter Effective Global Shutter Programmable Scan Mode
Digital Binning	Symmetrical and Asymmetrical Binning up to 4x4 pixels
Linearity	>99%
Cooling Options	Air Cooled Liquid Cooled

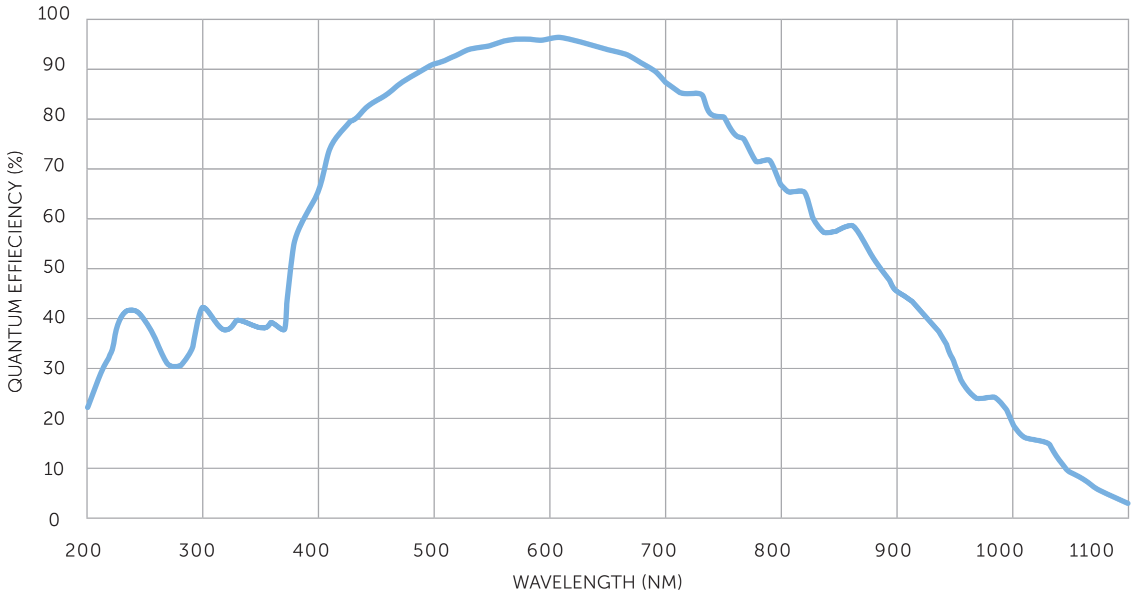
Camera Modes

Specifications	Dynamic Range	Speed	Sensitivity (CMS)	Sub-Electron (8x CMS)
Bit-Depth	16-bit	8-bit	12-bit	16-bit
Frame Rate (Full Frame)	83 fps	498 fps	88 fps	5.2 fps
Read Noise	$1.6e^-$	$2.0e^-$	$1.2e^-$	$0.7e^-$
Cooling	0° C	0° C	0° C	0° C
Line Time	3.749 µsec/line	0.625 µsec/line	3.53125 µsec/line	60.1 µSec/line
Dark Current	1.27 e^-/p/sec	3 e^-/p/sec	1.03 e^-/p/sec	0.477 e^-/p/sec
Conversion Gain	0.23 e^-/count	0.85 e^-/count	0.25 e^-/count	0.015 e^-/count
Full Well Capacity	15000 e^-	200 e^-	1000 e^-	1000 e^-

Specification	Camera Interface
Digital Interface	PCI-Express Gen 3 USB 3.2 10 Gbps
Lens Interface	T-Mount F-Mount C-Mount Swappable Mounts
Mounting Points	2x 1/4" mounting points per side
Camera Weight	1.8 Kg, 4 lbs

Triggering Mode	Function
Input Trigger Modes	Trigger First: Sequence triggered on first rising edge Level Trigger: Exposure time is controlled by length of high trigger signal Edge Trigger: Each frame in sequence triggered by rising edge SMART Streaming: Fast iteration through multiple exposure times works with the 4 trigger outs to control multiple sources at multiple exposure time
Output Trigger Modes	Any Row: Expose signal is high while any row is acquiring data First Row: Expose signal is high while first row is acquiring data. Line Output: Expose signal provides rising edge for each row advanced by the rolling shutter readout
Effective Global Shutter Trigger Modes	All Rows: Expose out signal is high for Exposure time this keeps exposure time but drops frame rate Rolling Shutter: Expose out signal is high for Exposure time - readout time this keeps frame rate but drops exposure time
Output Trigger Signals	Expose Out (up to four signals), Read Out, Trigger Ready

TELEDYNE IMAGING
Everywhereyoulook™



Accessories (Included)

USB 3.2 Card/Cable

Trigger Cable

Power Supply

Quickstart Guide

PCIe Card/Cable

Accessories (Additional)

Liquid Circulator

Liquid Cooling Tubes

Frame Rate

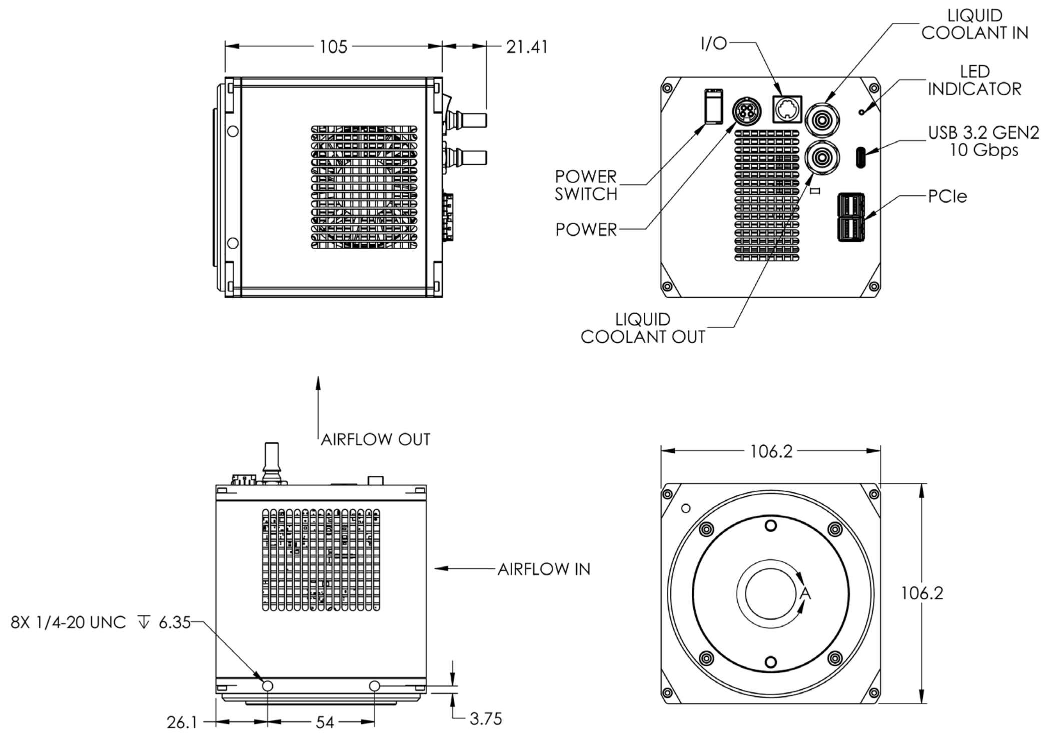
Array Size	Dynamic Range		Speed		Sensitivity (CMS)		Sub-Electron	
	PCI-E	USB	PCI-E	USB	PCI-E	USB	PCI-E	USB
3200 x 3200	83	39	498	79	88	52	5.2	5.2
3200 x 2304	115	54	691	110	122	72	7.2	7.2
3200 x 2048	130	61	778	122	138	81	8.1	8.1
3200 x 1600	166	78	996	158	176	104	10.4	10.4

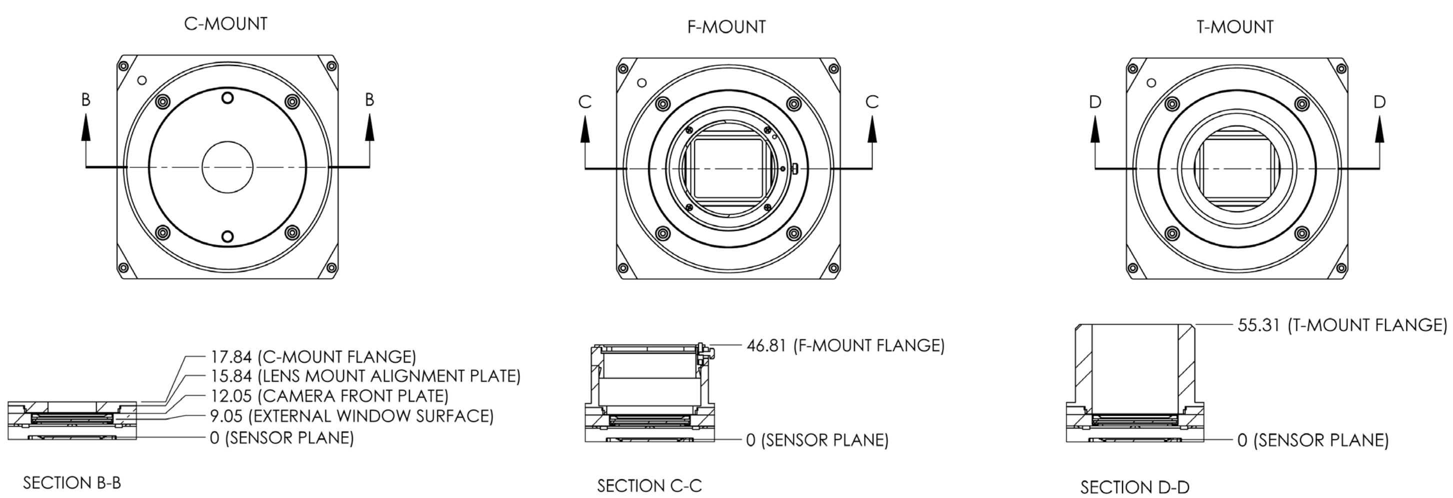
Line Scan ROI Frame Rates in KHz

Array Size	Dynamic Range	Speed	Sensitivity (CMS)	Sub-Electron
3200 x 64	4.1	21.1	4.3	0.2
3200 x 32	8.1	36.4	8.3	0.5
3200 x 16	15.7	57.1	15.7	0.8
3200 x 8	29.6	80.0	28.3	1.4
3200 x 4	53.3	99.4	47.2	2.1
3200 x 2	88.9	107.2	47.2	2.7

Based on measurement using PCIe interface on a Kinetix having firmware 30.32.1

Kinetix Mechanical drawings
Units in Millimetres





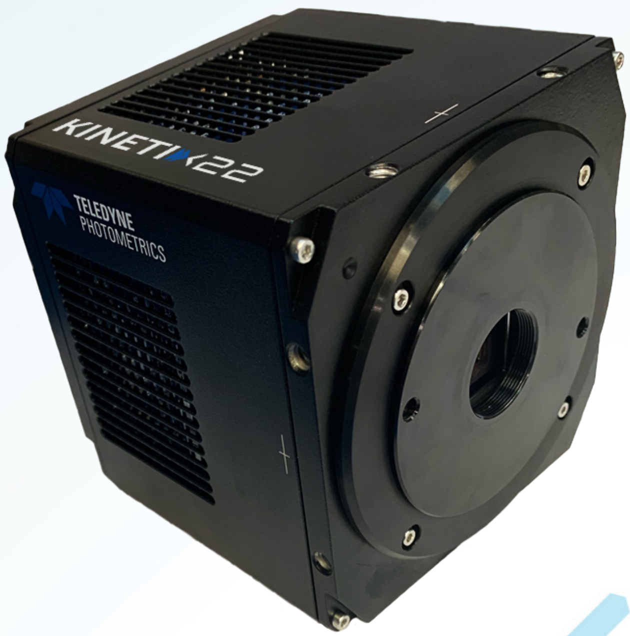
Making Custom Adapters:

The lens adapters thread into a M48 x 1mm female lens mount alignment plate on the front of the Kinetix. The depth is nominally 3.79mm and it's recommended to use a male thread of 3.53mm in length.

TELEDYNE PHOTOMETRICS
Everywhereyoulook™

KINETIX22

High Speed, Back-Illuminated sCMOS



22 mm Field Of View
5.76 Megapixel 2400x2400
6.5 µm Pixels
498 Frames Per Second
95% Quantum Efficiency
0.7 e- Read noise

Specifications	Camera Performance
Sensor	Teledyne Photometrics Kinetix Sensor
Active Array Size	2400 x 2400 (5.76 Megapixel)
Pixel Area	6.5µm x 6.5µm (42.25 µm^2)
Sensor Area	15.6 mm x 15.6 mm 22 mm diagonal
Peak QE%	>95%
Readout Mode	Rolling Shutter Effective Global Shutter Programmable Scan Mode
Digital Binning	Symmetrical and Asymmetrical Binning up to 4x4 pixels
Linearity	>99%
Cooling Options	Air Cooled Liquid Cooled

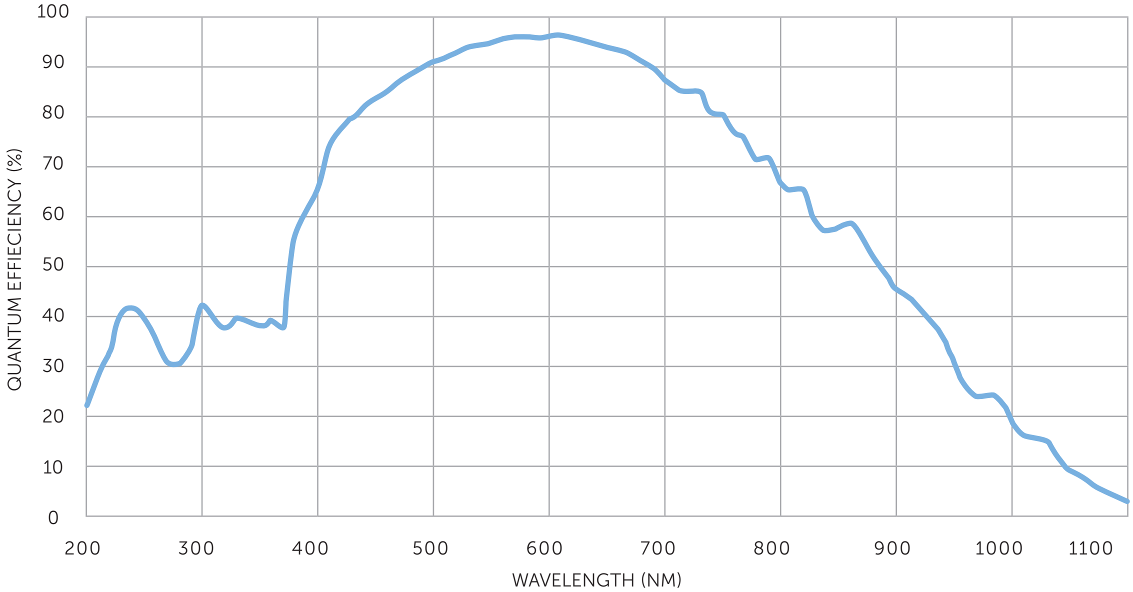
Camera Modes

Specifications	Dynamic Range	Speed	Sensitivity (CMS)	Sub-Electron (8x CMS)
Bit-Depth	16-bit	8-bit	12-bit	16-bit
Full Frame Rate	83 fps	498 fps	88 fps	5.2 fps
Read Noise	1.6e$^-$	2.0e$^-$	1.2e$^-$	0.7e$^-$
Cooling	0° C	0° C	0° C	0° C
Line Time	5 µsec/line	0.836 µsec/line	4.71 µsec/line	80.12 µsec/line
Dark current	1.27 e$^-$/p/sec	3 e-/p/sec	1.03 e-/p/sec	0.477 e-/p/sec
Conversion Gain	0.23 e-/count	0.85 e-/count	0.25 e-/count	0.015 e-/count
Full well capacity	15000 e-	200 e-	1000 e-	1000 e-

Specification	Camera Interface
Digital Interface	PCI-Express Gen 3 USB 3.2 10 Gbps
Lens Interface	C-Mount
Mounting Points	2x 1/4"-20 TPI mounting points per side
Camera Weight	1.8 Kg, 4 lbs

Triggering Mode	Function
Input Trigger Modes	Trigger First: Sequence triggered on first rising edge Level Trigger: Exposure time is controlled by length of high trigger signal Edge Trigger: Each frame in sequence triggered by rising edge SMART Streaming: Fast iteration through multiple exposure times works with the 4 trigger outs to control multiple sources at multiple exposure time
Output Trigger Modes	Any Row: Expose signal is high while any row is acquiring data First Row: Expose signal is high while first row is acquiring data. Line Output: Expose signal provides rising edge for each row advanced by the rolling shutter readout
Effective Global Shutter Trigger Modes	All Rows: Expose out signal is high for Exposure time this keeps exposure time but drops frame rate Rolling Shutter: Expose out signal is high for Exposure time - readout time this keeps frame rate but drops exposure time
Output Trigger Signals	Expose Out (up to four signals), Read Out, Trigger Ready

TELEDYNE IMAGING
Everywhereyoulook™



Accessories (Included)

USB 3.2 Cable and Card

Trigger Cable

Power Supply

Quickstart Guide

PCle Card and Cable

Accessories (Optional)

Liquid Circulator

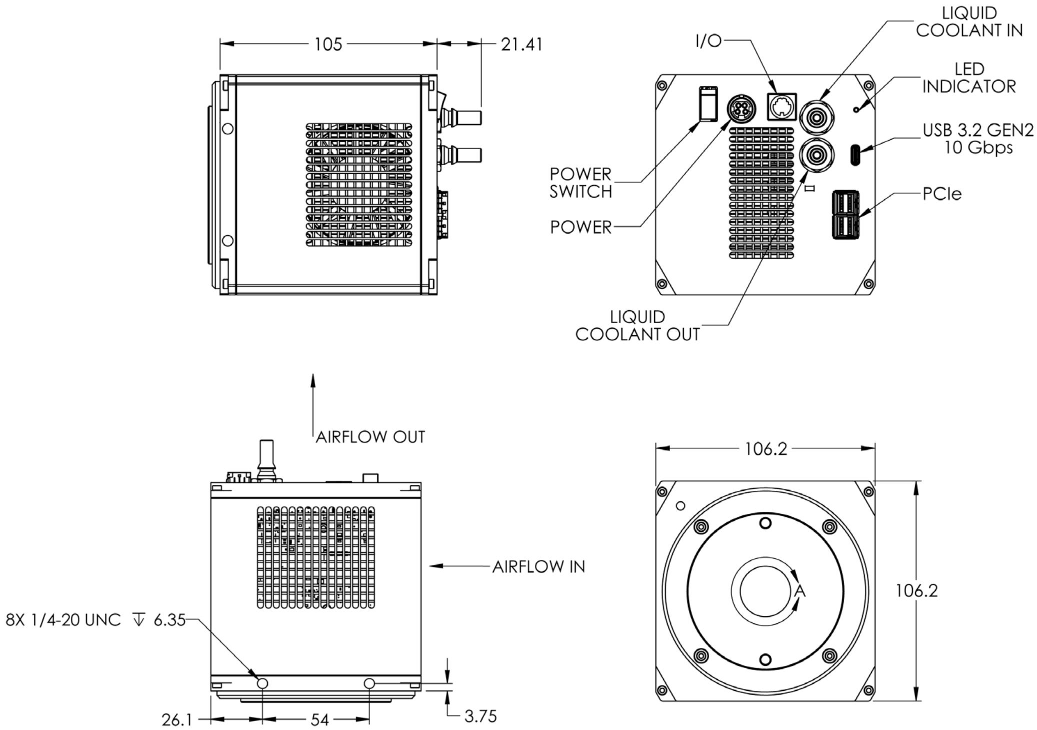
Liquid Cooling Tubes

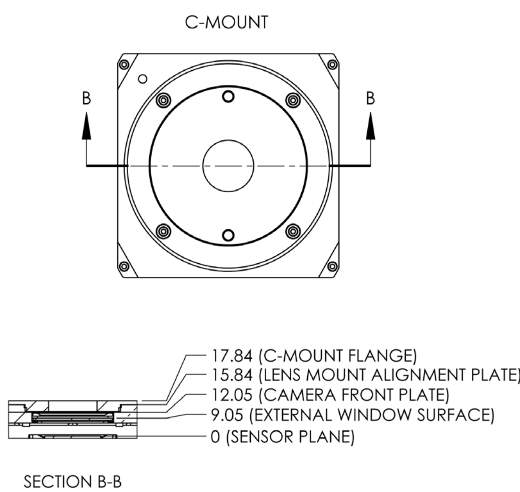
Frame Rate

Array Size	Dynamic Range		Speed		Sensitivity (CMS)		Sub-Electron	
	PCI-E	USB	PCI-E	USB	PCI-E	USB	PCI-E	USB
2400 x 2400	83	70	498	138	88	88	5.2	5.2

Kinetix Mechanical drawings

Units in Millimetres





Specifications in this datasheet are subject to change. Refer to the Teledyne Photometrics website for most current specifications.

Kinetix Family Software Support

Supported Software

- Nikon NIS-Elements
- Visitron VisiView
- Intelligent Imaging Innovations (3i) SlideBook 6
- National Instruments LabVIEW
- MathWorks MATLAB
- Python 3.6
- Open CV
- Micro-Manager
- Camera driver SDK available for developers

Supported Operating Systems

- Windows 10 64-bit
- Linux

Notes

We recommend contacting your local third-party software office for minimum version numbers, support and relevant information.

Teledyne Photometrics

WWW.PHOTOMETRICS.COM