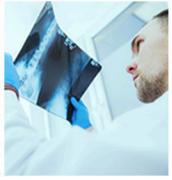

Unveiling Andor CB2 24B - From the Astronomically Large to the Microscopically Small

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OXFORD INSTRUMENTS
ANDOR

In the dynamic realms of low light microscopy and astronomy, the pursuit of large field of view and high resolution with no compromise on speed drives the evolution of imaging technologies. Oxford Instruments is committed to providing scientists with the most cutting edge cameras. The Andor CB2 24B by First Light Imaging is crafted for multiple and diverse applications, including microscopy, and draws upon a decade of heritage in the astronomy domain.

Why Andor CB2 24B?

Scientific CMOS camera
Global shutter - High speed – Low noise
14.6 mm by 12.6 mm with 2.74 µm pitch

Read the Specification Sheet for more information.

Designed specifically around the CMOS IMX530 sensor from Sony, which provides a small pixel pitch across a large area, the Andor CB2 24B camera is a breakthrough combining high sensitivity and high resolution over a large sample field-of-view. Thanks to its 2x2 on-chip binning, Andor CB2 24B uniquely allows the native 2.74 µm pixels to be converted to a 5.78 µm *without doubling of readout noise*. For your experiments requiring long exposure times, Andor CB2 24B stands out from the competition thanks to its very low dark current. By suppressing the need for stitching/mosaicing and allowing high speed snapshot imaging, the camera enables groundbreaking high-speed large field of view live imaging of microscopy features and dynamics.

Main features	
Sensor size (W x H)	5328 x 4608 (24.5 MP)

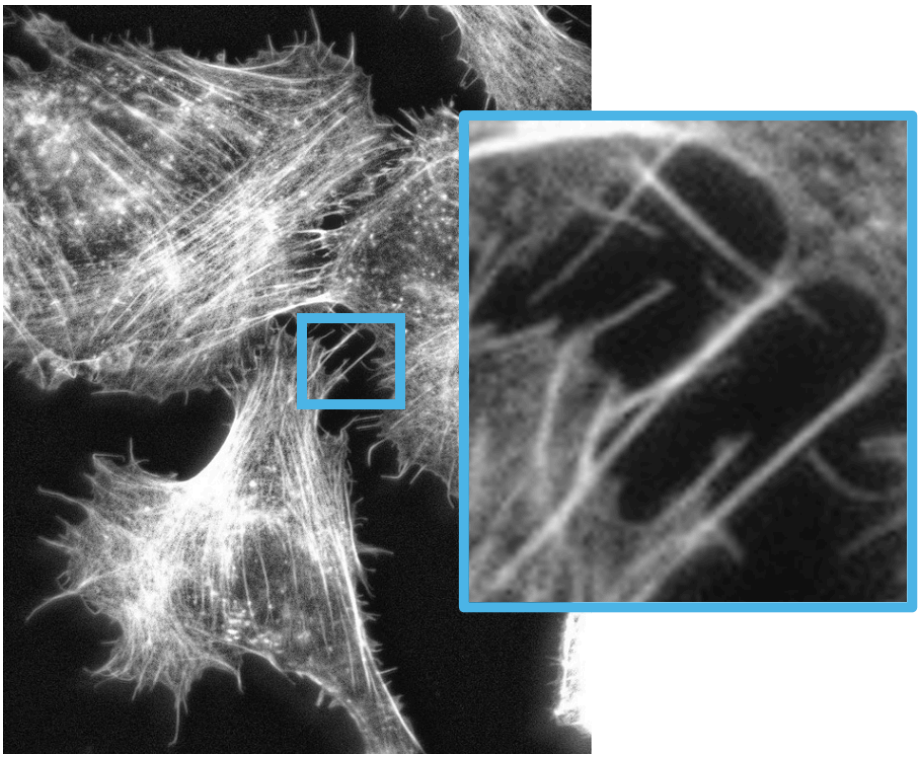
Pixel pitch	2.74 um (5.48 um with 2x2 on-chip binning)
Dynamic range	80 dB (HDR)
Speed (full frame, 12-bits) CoaXPress SFP+ 10GB (Ethernet or Fiber)	74 fps 32fps
Interface	CoaXPress 2.0 (CXP-12, 4 ports) SFP+ 10 GB interface (Ethernet or Fiber)
Readout noise	1.30 e- RMS
Dark current	0.0015 e^-/p/s at -20°C 0.0044 e^-/p/s at 0°C
Full well capacity (0 dB)	9500 e-

Mechanical features	
Size	H77.5 x W93.0 x L177.5 mm
Weight	1.1 kg
Max Power consumption	60 W
Front filter thread	C-/TFL- Mount

The camera offers a high degree of cooling, down to -20°C, thanks to its integrated liquid cooling circuit and fan. This offers high flexibility to use the camera at long exposure times such as bioluminescence in-vivo imaging or astronomy. In high-speed applications, the sensor stabilization will ensure high precision in the repeatability of focal plane positioning.

The camera is fully integrated into First Light Vision graphical user interface and the associated SDK (C, C++; C#, Python, MATLAB, LabVIEW, Halcon). It is also integrated into the popular Micromanager microscopy acquisition software platform.

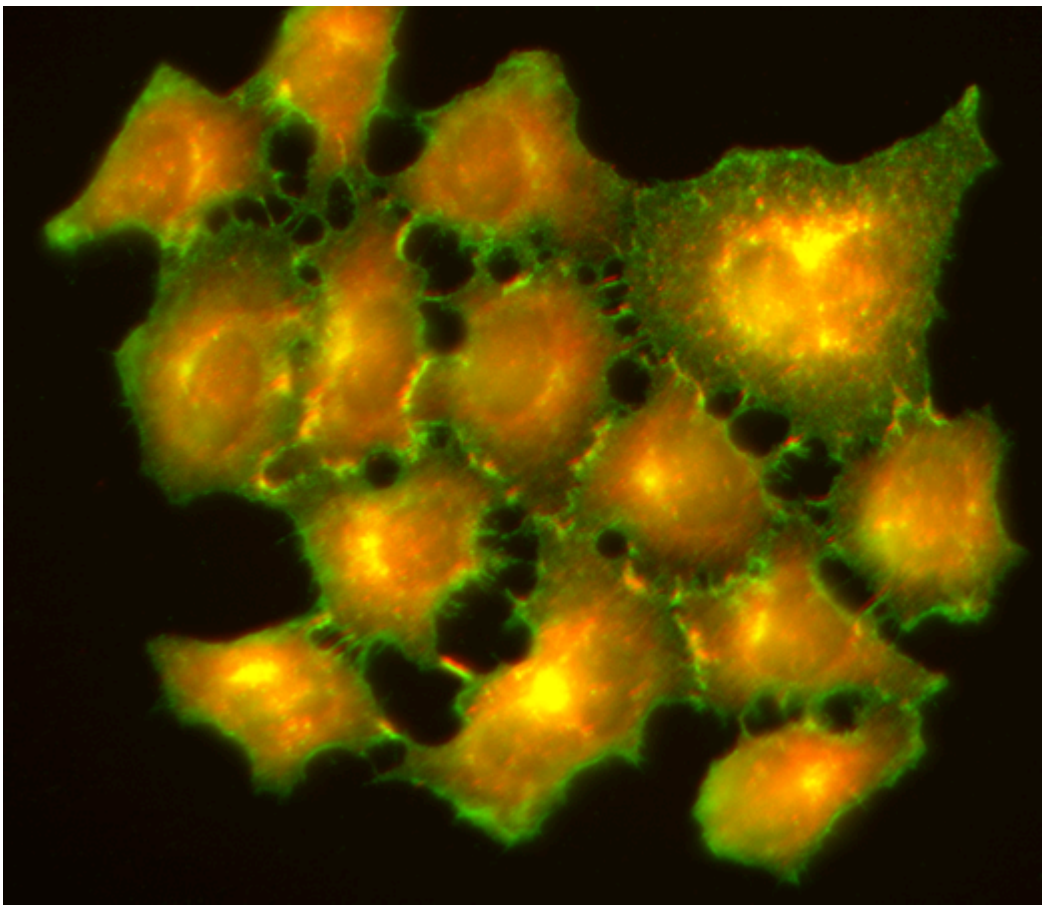
Introduction to Resolution in Microscopy



High resolution fluorescence image of U2-OS cells labeled with phalloidin-AlexiaFluo 568 (actin)

As is the case in astronomy, resolution in microscopy is the shortest distance between two points that can be distinguished. It is determined mainly by two factors: microscope resolution and camera resolution.

Microscope resolution is a function of the numerical aperture (NA) of the objective lens and the emission wavelength of the sample. However, it is ultimately limited by the diffraction limit, roughly 220 nm at 510 nm (green light). The camera resolution is the ability of the camera to detect what the microscope can resolve; it is determined primarily by pixel size, although Signal to Noise Ratio is also an important factor in terms of resolving ability.



Fluorescence image of U2-OS cells.
Green : septine. Red : actine.

Objective magnification has no impact on the microscope resolution, only numerical aperture is important. A 100x, 1.30 NA objective has the same resolving power as a 40x 1.30 NA objective. By using lower magnification objectives, the field of view drastically increases, going from a 100x to a 40x leads to an increase of the field of view of 450%. This is illustrated on the left.

When designing a microscopy system, the goal is to match the diffraction limited resolution of the microscope to two pixels on the sensor. This is called Nyquist sampling and can be computed using the equation:

$$Resolution = 2.3 \cdot \frac{pixel\ size}{objective\ magnification}$$

A small pixel pitch allows for lower magnification to be used which increases the field-of-view, while maintaining the resolution.

Field-of view at the sample level is defined by the equation:

$$FOV = \frac{[nb\ of\ pixels\ y\ \cdot pixel\ size] * [nb\ of\ pixel\ x\ \cdot pixel\ size]}{objective\ magnification}$$

In microscopy, capturing a wide field of view is key to achieving a thorough specimen analysis. The Andor CB2 24B transcends conventional limitations, providing a generous field of view without compromising the resolution. This achievement at sensor level will transform the way microscopists perceive and analyze their

samples.

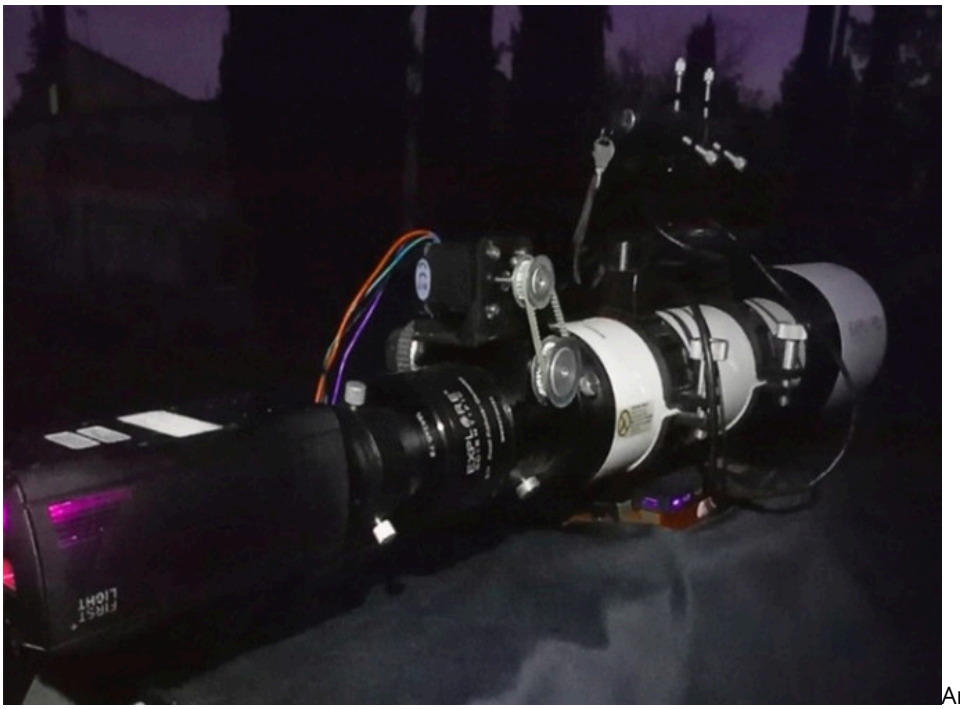
Use Case #1: From the Astronomically Large...

Context

Andor CB2 24B was carefully tested to evaluate its performance in real-world astronomical applications. Through the utilization of both full frame and high sensitivity binning modes, we aimed to thoroughly assess the capabilities of the Andor CB2 24B camera in capturing high-quality astronomical data. In astronomical observations, long exposure times are usually achieved by combining multiple images, 50 seconds of exposure being a standard value.

Methods

In this study, we employed two distinct amateur astronomical observation set-ups to thoroughly assess the performances of the cooled Andor CB2 24B camera.



Andor CB2 24B prototype coupled to a 102 mm lens

For testing the full frame mode, Andor CB2 24B was coupled to an optical lens featuring specifications of 102 mm and a focal length of 500 mm. The imaging system is shown on the right. The lens, an APO ED (FCD 100 glass), provided the necessary configuration for capturing images with a field of view of 1.6° at a measurement scale on sky of 2.4 µm/ arsec, *i.e.*, 1.16 arcsec/pixel.

To evaluate the binning mode, Andor CB2 24B was paired to a 406 mm telescope featuring a focal length of 1870 mm, alongside a coma corrector and RAF LRVB configuration. This setup enabled us to achieve a measurement scale on sky of 9.1 µm/arcsec, *i.e.*, 0.6 arcsec/pixel over a field of view of 50 arcmin.

Results

We showcase the versatility and performance of the Andor CB2 24B camera in capturing the intricate details of celestial objects over large fields of view. These results highlight the exceptional imaging capabilities of the Andor CB2 24B camera across different observational configurations.

A color-composite image of the Pleiades, also known as M45
Andor CB2 24B in full frame mode (45 x 50s exposure)

A black and white image of the M109 galaxy Andor CB2 24B in binning mode (60 x 50s exposure)

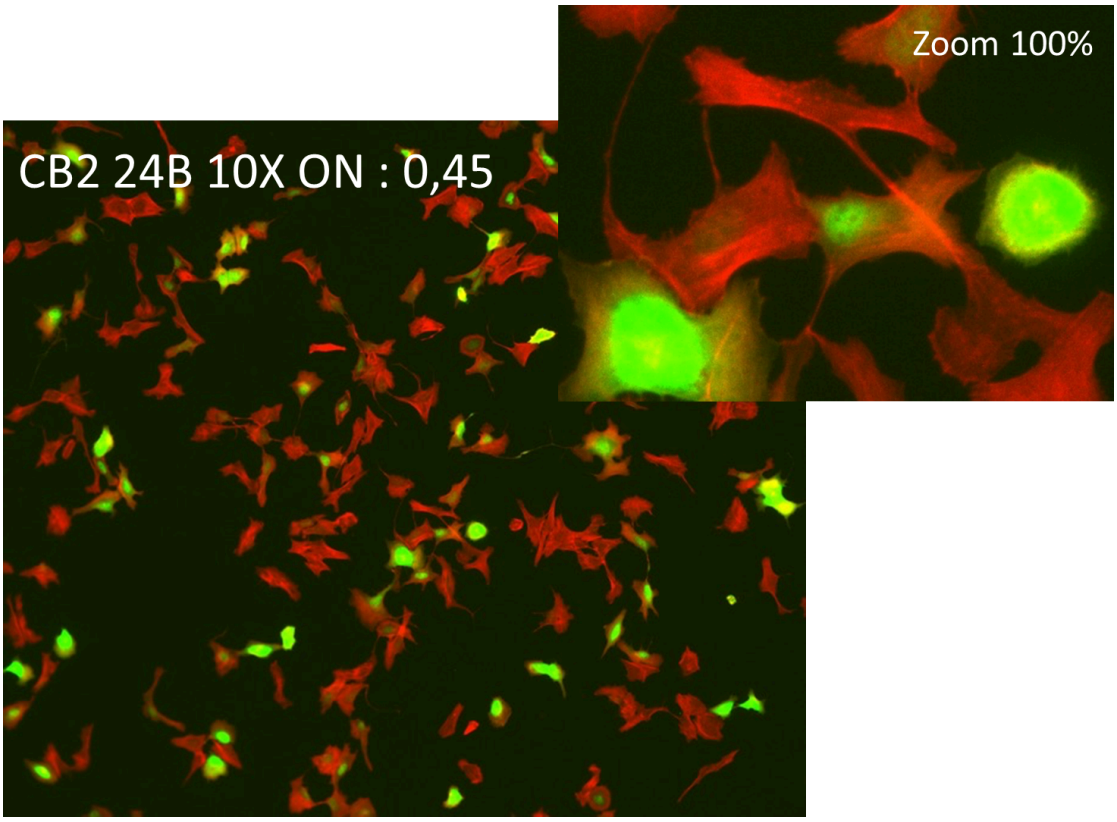
Let us now shift our focus from the infinite world of astronomy to the realm of microscopy...

Use Case #2: ... to the Microscopically Small

Context

The purpose of the work shown here is to illustrate the added value of the Andor CB2 24B camera for low magnification microscopy. High quality objectives can combine a low magnification with a large numerical aperture. In this use case, the microscope resolution offers a small Point Spread Function (PSF), to which the small pixel size will be a great advantage.

Large Field-of-View Imaging



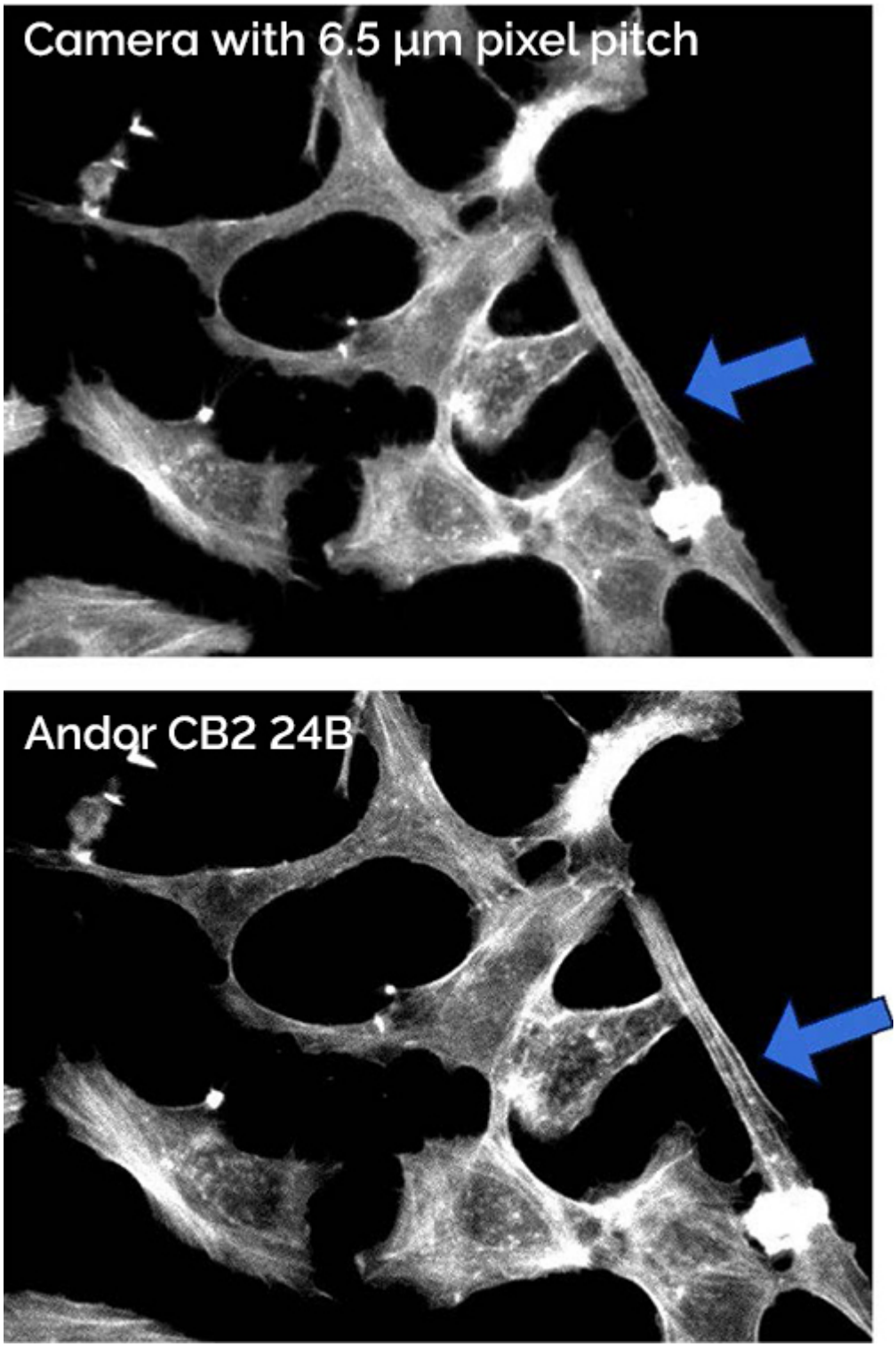
U2-OS cells fixed and fluorescently labeled, observed with Andor CB2 24B using a 10x objective with a numerical aperture of 0.45.
Green : septin. Red : actin.

Using a 10X objective with Andor CB2 24B, we capture four times more cells in a single acquisition than at 20X, while still retaining the ability to digitally zoom into the image to obtain a level of overall information close to what is achieved with the higher magnifications and a standard larger pixel camera. For studies involving determining and quantifying the location and distribution of florescence signal over a large sample area, low-magnification Andor CB2 24B acquisitions are of major interest.

High Resolution

In microscopy, the mainstream population of scientific sCMOS cameras showcase a 6.5 µm pixel pitch, optimized to meet the Nyquist criterion at a magnification of 60X. The use of a 10X objective with a numerical aperture of 0.45 is limiting for such a camera. Indeed, the PSF of 14 µm corresponds to only 2.15 pixels, which is very close to the Nyquist criterion required for adequate sampling of an image. With Andor CB2 24B on this type of objective, the images obtained are of better quality than with a 6.5 µm camera.

We find that for other magnifications that allow the Nyquist criterion to be barely met for a 6.5 µm camera, the images obtained are generally better with Andor CB2 24B in terms of accessible detail.



Fluorescence images of U2-OS cells, actin labeling with phalloidin-AlexaFluor 568. Display of the same areas (zoomed in), showing that details are more visible on the Andor CB2 24B than on a 6.5 µm pixel pitch camera.

Andor CB2 24B
&
Low magnification, high numerical aperture objective lens

Conclusion

The comprehensive assessment of the Andor CB2 24B camera, as reported in this paper, has demonstrated its remarkable versatility and performance across diverse applications in both astronomy and microscopy.

The exceptional, adaptable and versatile imaging capabilities of the Andor CB2 24B camera have been particularly exemplified in microscopy, where it excels in providing high-resolution images with extensive fields of view, facilitating detailed analysis and statistical exploration of microscopic specimens.

Through our astronomical observations, we have showcased the camera's ability to capture the intricate details of celestial objects over large fields of view, as evidenced by the stunning images of the Pleiades star cluster and the M109 galaxy.

Overall, the Andor CB2 24B camera emerges as a powerful and reliable tool for researchers and enthusiasts alike, offering unparalleled imaging quality and flexibility across various scientific disciplines.

Note: We warmly thank the Institut Fresnel and INSERM’s teams for the microscopy images.