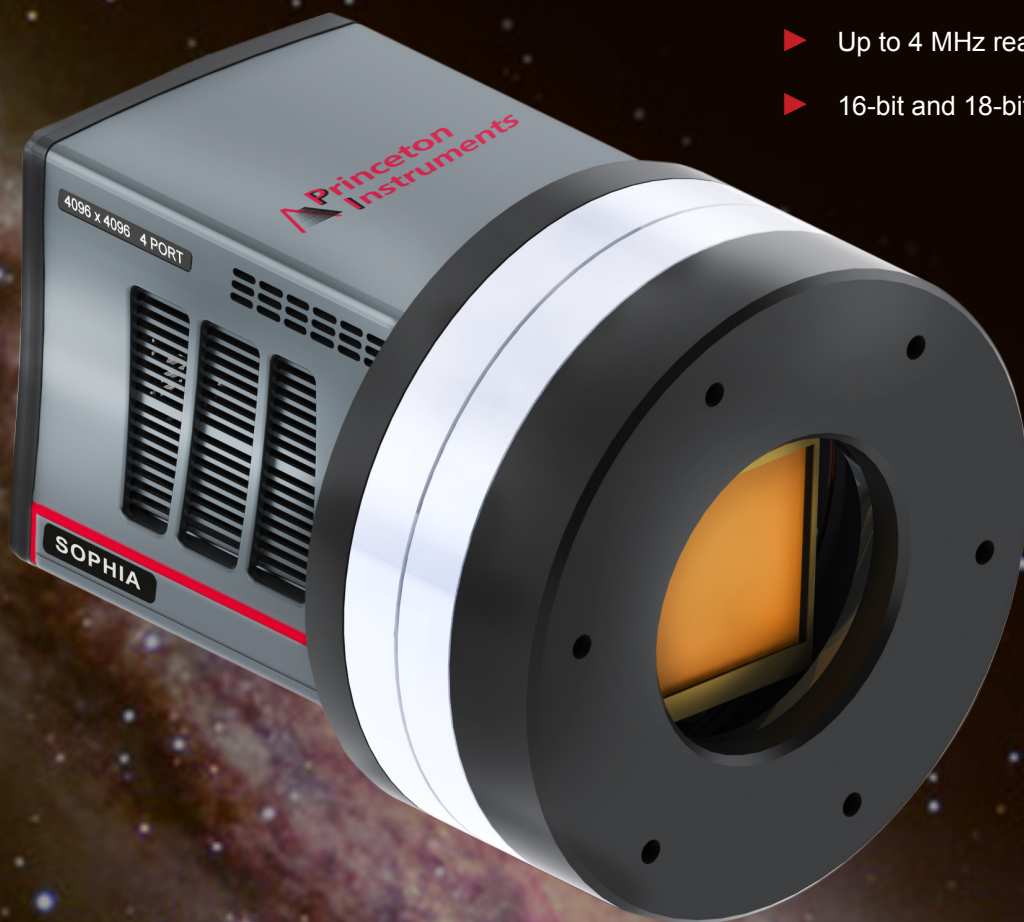


# SOPHIA® 4096B

DEEP-COOLED, ULTRA-LARGE-FORMAT CCD CAMERAS

## Datasheet



- ▶ 4096 x 4096 sensor format  
15 x 15 micron pixel size  
61.4 x 61.4 mm imaging area
- ▶ ArcTec™ technology for maximum deep cooling
- ▶ Read noise as low as 2.0 e<sup>-</sup> rms
- ▶ 150,000 / 350,000 well depth
- ▶ Up to 4 MHz readout (quad port)
- ▶ 16-bit and 18-bit digitization



**TELEDYNE**  
**PRINCETON INSTRUMENTS**  
Everywhere you look™

# Breakthrough Scientific Imaging



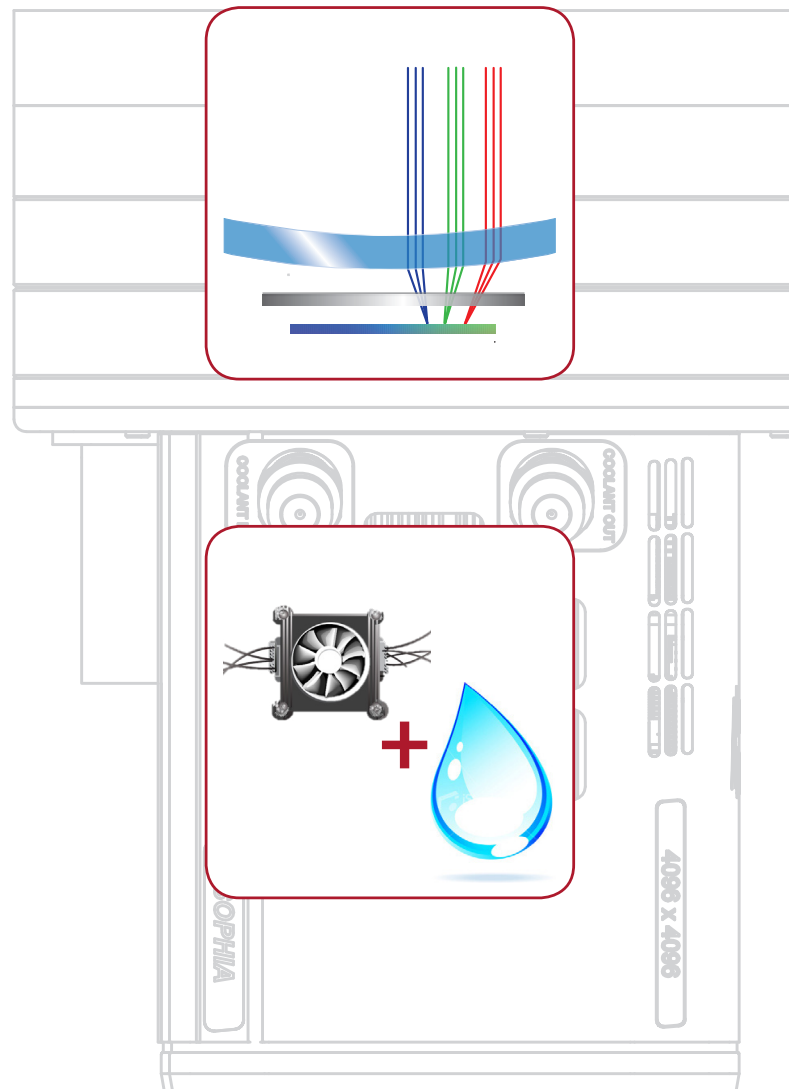
## Great choices:

- ▶ The SOPHIA 4096B-154 features the e2v CCD230-84 back-illuminated sensor, which provides an expansive 61.4 x 61.4 mm imaging area, 4096 x 4096 pixel resolution, and large 15  $\mu\text{m}$  pixels.
- ▶ The SOPHIA 4096B-154A model incorporates the e2v CCD231-84 “astro” back-illuminated sensor, combining exceptionally low read noise with a very large well depth.

SOPHIA cameras are ideal for applications ranging from astronomy to fluorescence imaging.

## Key Camera Features:

- ▶ **Better Optical Design:**  
Improved field-flattener performance with reduced window-to-CCD-surface distance along with minimized window thickness. Optimized design improves edge sharpness and lowers the distortion.
- ▶ **Air and Water Cooling:**  
SOPHIA cameras reach deep temperatures without liquid nitrogen or cryocoolers, so there are no requirements for storage or bulky equipment. The SOPHIA 4096B is designed for remote operation.



► **Shutter Options:**

Supports an integrated high-performance 90 mm mechanical shutter or provides software control of external shutters. The integral shutter is field replaceable, reducing downtime and cost.

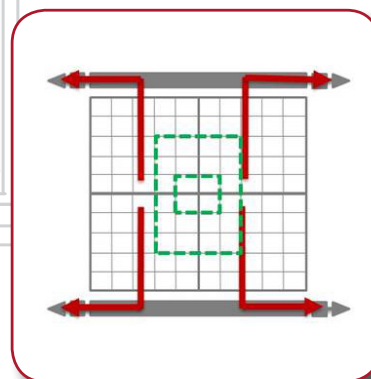
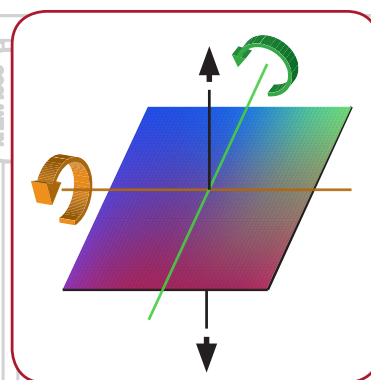
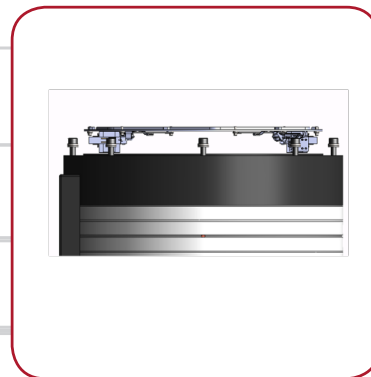
► **CCD Positioning:**

Incorporates the ability to “zero out” the variability in the mechanical assembly so as to achieve precise and repeatable CCD orientation. The CCD can be adjusted for tilt, pitch, and z-axis translation, reducing the requirement for system-level adjustments.

► **When Speed is Paramount:**

The SOPHIA 4096B has the most advanced readout electronics:

- 4-port simultaneous readout
- Multiple ADC speeds (up to 16 MHz)
- Binning and ROI readout
- Custom readout modes for microsecond exposures



achieve precise and repeatable CCD orientation

► **Lifetime Vacuum Guarantee:**

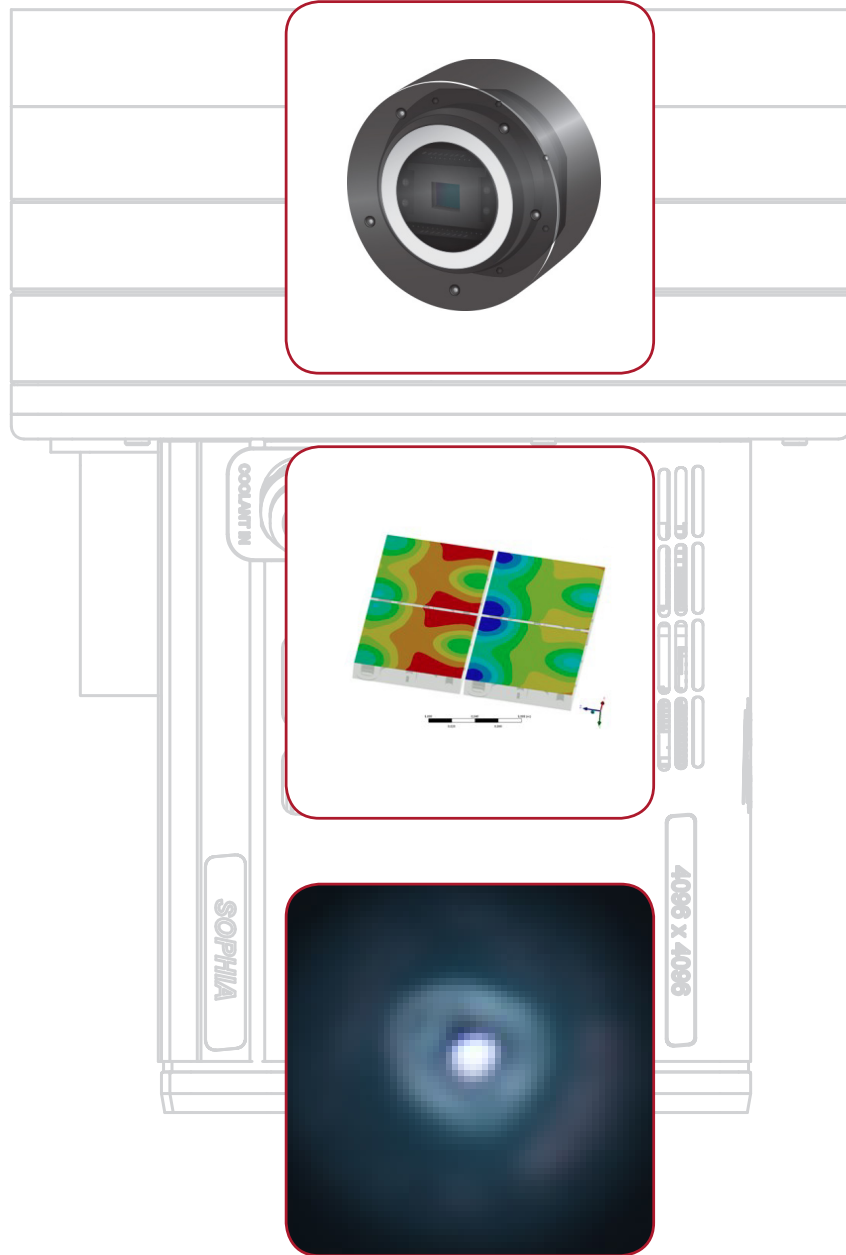
Decades of expertise ensure the most reliable vacuum design in the industry. ArcTec technology utilizes an all-metal, hermetic vacuum seal with no epoxies. Princeton Instruments is the only scientific imaging company that guarantees both cooling temperature and vacuum for the lifetime of the camera.

► **Multi-TEC Design:**

A complete redesign of the CCD cooling mechanism and vacuum chamber guarantees even heat dissipation for very large CCD formats. Designed to withstand thermal cycling and ensure repeatable CCD positioning and alignment.

► **Wide Dynamic Range:**

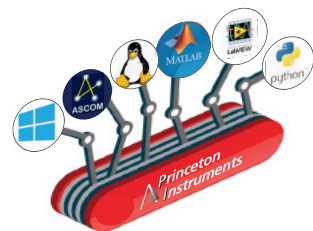
Extremely low noise, maximum well depth, 18-bit digitization, and dark current below the zodiacal photon background enable extremely long exposure times for weak-signal detection.



► **We give you the most options!**

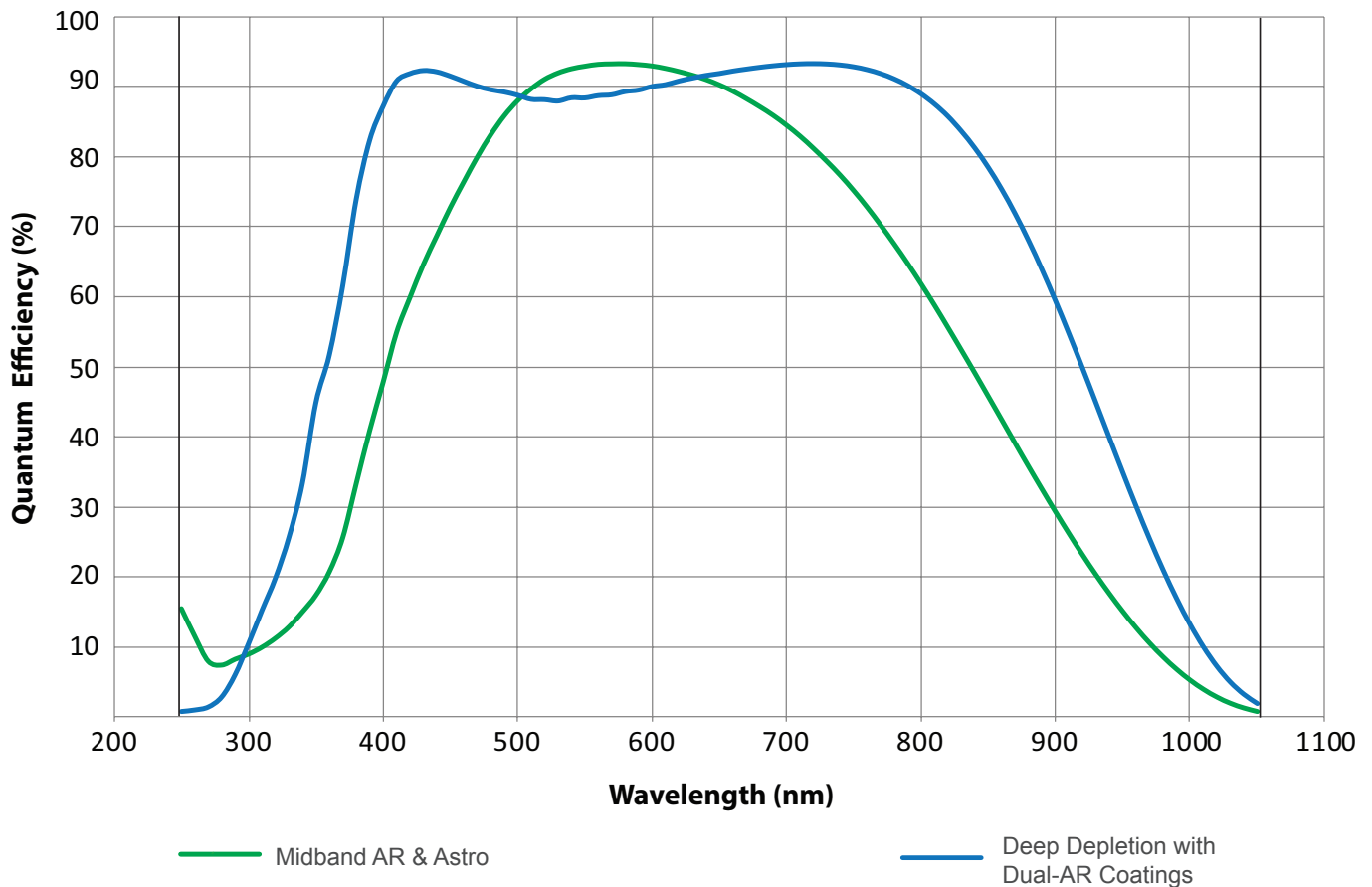
The SOPHIA 4096B is a perfect solution for the most challenging low-light applications:

- Air or liquid cooling
- Microsoft® Windows® 10 or Linux® 64-bit operating system support
- Seamless integration of controls and data acquisition into MATLAB® (MathWorks), LabVIEW® (National Instruments), ASCOM, Maxim DL™ (Cyanogen Imaging), and Python®
- SDK / API compatible with Microsoft Windows and Linux

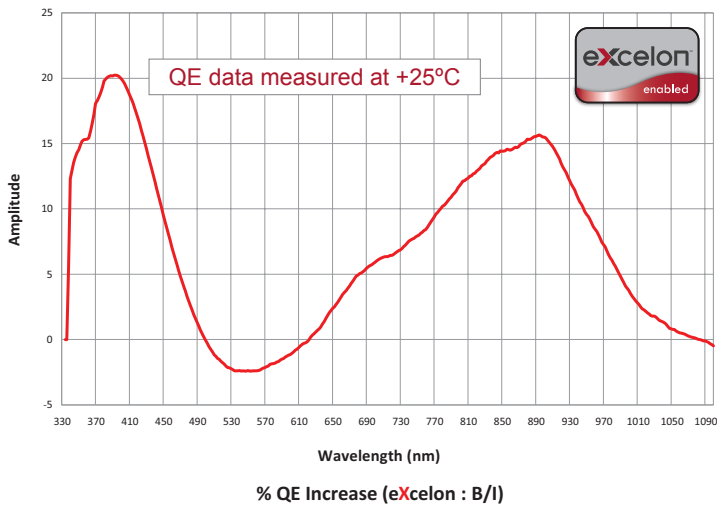


► **CCD Options:** Anti-reflection (AR) coatings on back-illuminated CCDs further improve quantum efficiency.

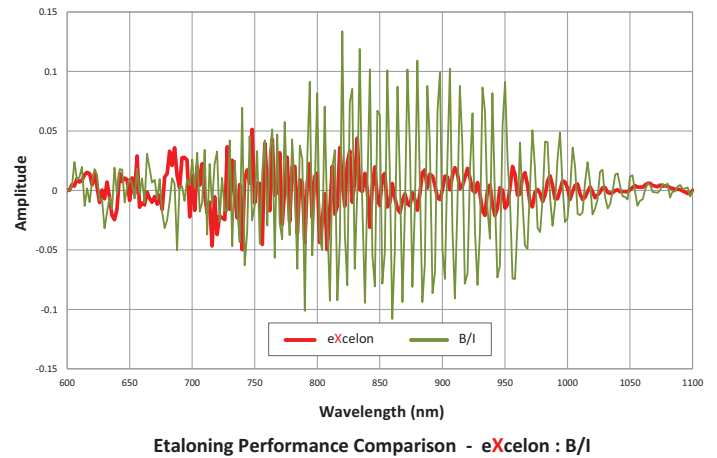
- Standard midband AR coating, available on the SOPHIA 4096B-154 and -154A, optimizes the response in the visible range (with QE reaching 95%).
- Deep depletion with fringe suppression and dual-AR coatings, available on the SOPHIA 4096B-154A, increases the QE response between 400 and 1000 nm, making this option an excellent choice for emerging NIR applications. Fringe suppression reduces the etaloning effect in the NIR.



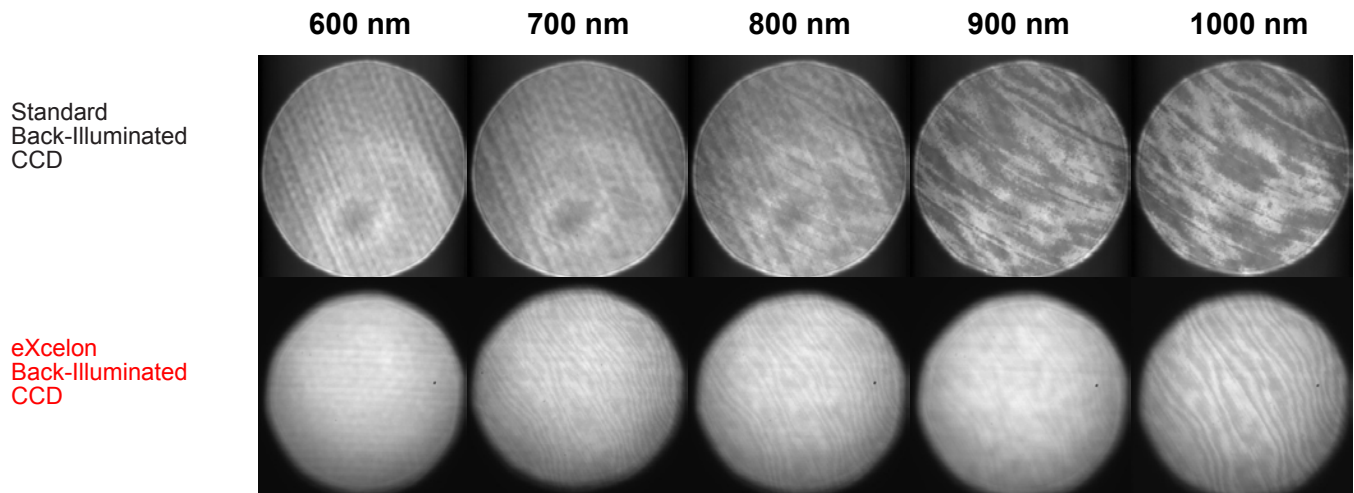
# eXcelon® Advantages



B\_eXcelon provides superior QE over the standard back-illuminated ("B/I") version in the UV-NIR range.



B\_eXcelon provides significantly lower etaloning (unwanted fringes) compared to standard back-illuminated ("B/I") version.



Data taken with white light source through a monochromator comparing etaloning performance of eXcelon vs. back-illuminated CCDs.

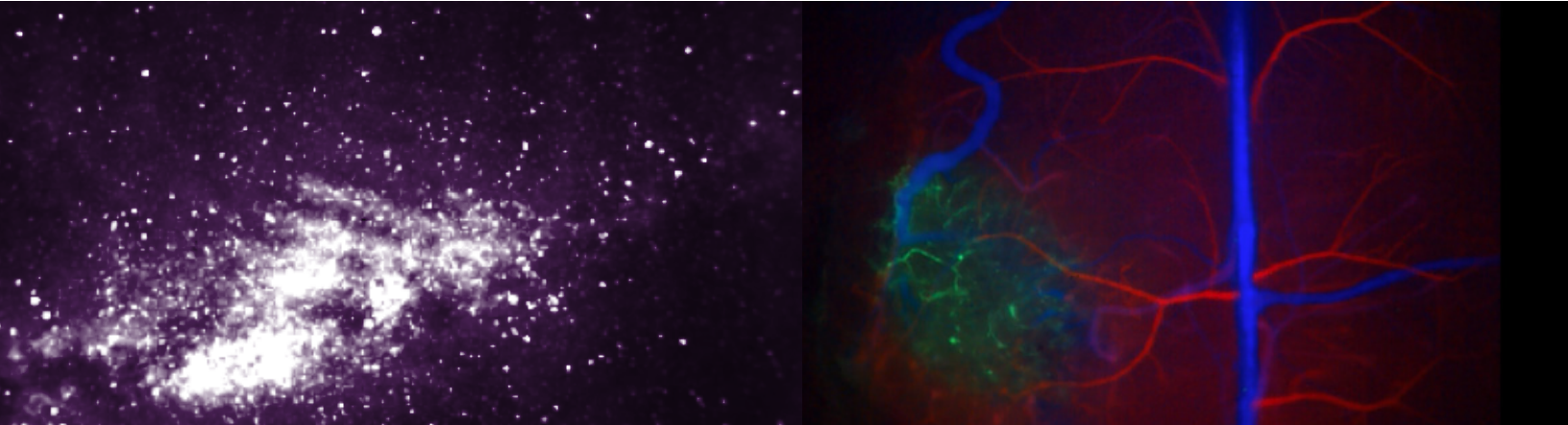


# SOPHIA 4096B Specifications

Feature	SOPHIA 4096B-154	SOPHIA 4096B-154A
CCD image sensor	e2v CCD230-84; scientific grade 1; AIMO. The large image area addresses demanding scientific imaging applications. Back-illuminated spectral response and low readout noise provide outstanding sensitivity. Available with midband coating (-MB version) or eXcelon process (-X version with proprietary eXcelon).	e2v CCD231-84; scientific grade 1; NIMO. The back-illuminated “astro” version offers higher full well capacity and lower readout noise than the CCD230-84 for demanding low-light applications. Astro midband (-MB version) and astro deep depletion with multiple AR coatings (-AR version) available.
CCD format	4096 x 4096 imaging pixels; 15.0 x 15.0 $\mu\text{m}$ pixels; 100% fill factor	
Imaging area	61.4 x 61.4 mm	
Deepest cooling temperature (@ +20°C)	< -90°C thermoelectric cooling with liquid chiller; < -60°C thermoelectric cooling with air	
Thermostating precision	$\pm 0.1^\circ\text{C}$	
Dark current (e <sup>-</sup> /pixel/sec)	0.0003 @ -60°C	0.8 @ -60°C
Cooling method	Thermoelectric air or liquid cooling (liquid chiller required)	
Full well	150 ke <sup>-</sup> (typical)	350 ke <sup>-</sup> (typical)
ADC speed	4 MHz, 2 MHz, 1 MHz, 100 kHz; 4-port readout	3 MHz, 1 MHz, 500 kHz, 100 kHz; 4-port readout
ADC bits	16 bits @ all ADC speeds; 18 bits @ 1 MHz and 100 kHz	16 bits @ all ADC speeds; 18 bits @ 500 kHz and 100 kHz
System read noise	<22 e <sup>-</sup> rms @ 4 MHz/port; <8.5 e <sup>-</sup> rms @ 1 MHz/port; <4.0 e <sup>-</sup> rms @ 100 kHz/port	<8.0 e <sup>-</sup> rms @ 3 MHz/port; <4.0 e <sup>-</sup> rms @ 1 MHz/port; <2.0 e <sup>-</sup> rms @ 100 kHz/port
Readout modes	4-port, 2-port, or 1-port readout; Kinetics; External Sync	
Nonlinearity	<1% @ 100 kHz	
Software-selectable gains	1, 2, 4 e <sup>-</sup> /ADU	
Data interface	USB 3.0 (5 m interface cable provided); Optional fiberoptic interface available for remote operation	
I/O signals	Two MCX connectors for programmable frame readout, shutter, trigger in	
Software (optional)	LightField for Microsoft Windows 10 (64 bit); PICam SDK for Microsoft Windows and Linux; Automation for third-party software	
Internal shutter	90 mm mechanical shutter with internal control or TTL	
External shutter	90 mm mechanical shutter with TTL control	
Certification	CE	
Operating environment	+5°C to +30°C non-condensing	
Camera head dimensions	See page 9	

*Specifications are subject to change.*

# SOPHIA 4096B Frame Rates



## Frame Rates (frames/sec)

### SOPHIA 4096B-154

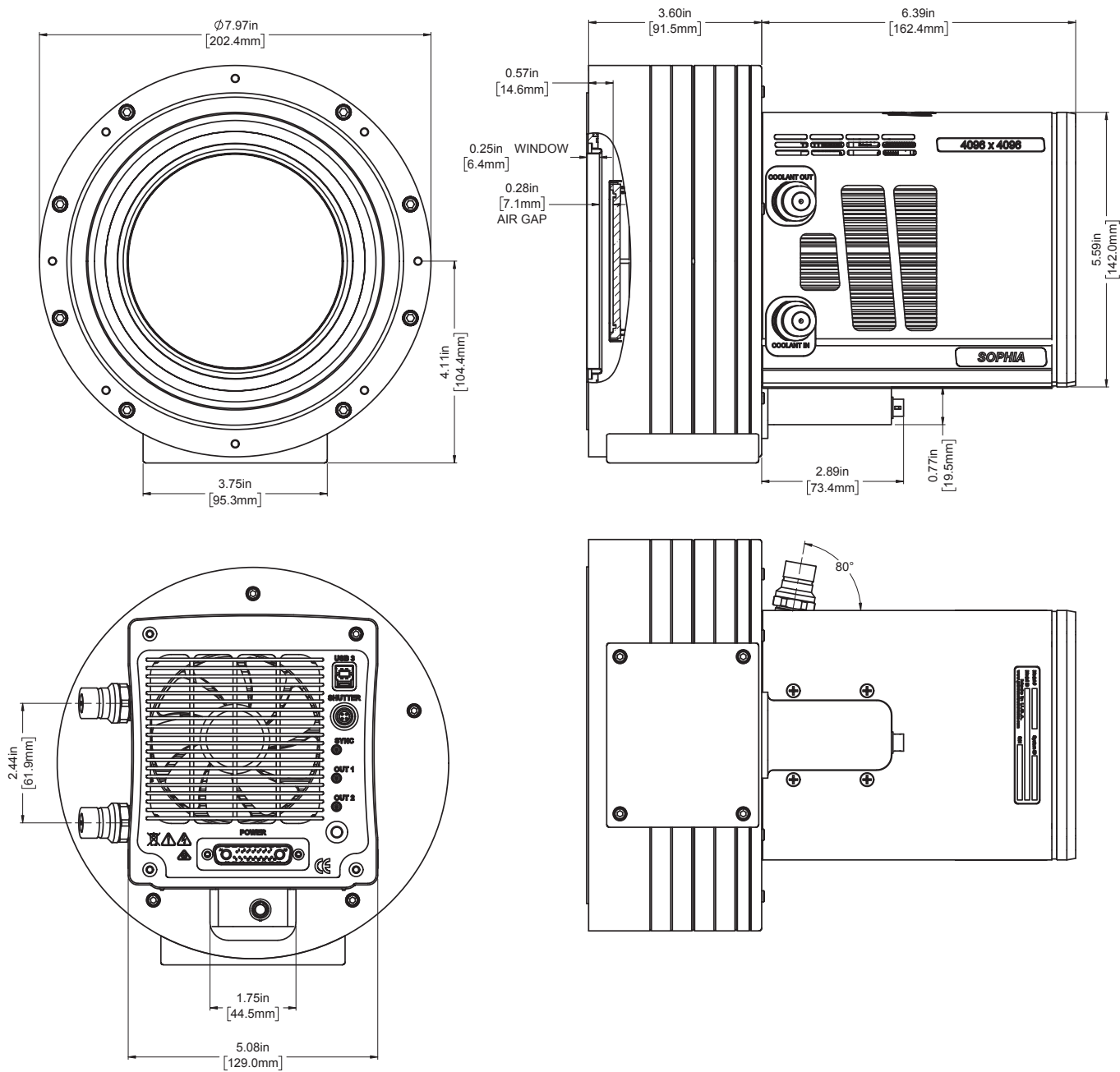
Readout Rate (MHz)	Region of Interest			
	4096 x 4096	2048 x 2048	1024 x 1024	512 x 512
4	0.44	0.66	0.88	1.05
2	0.29	0.47	0.70	0.91
1.0	0.18	0.32	0.51	0.74
0.1	0.023	0.044	0.086	0.16

### SOPHIA 4096B-154A

Readout Rate (MHz)	Region of Interest			
	4096 x 4096	2048 x 2048	1024 x 1024	512 x 512
3	0.50	0.81	1.17	1.51
1	0.21	0.37	0.63	0.98
0.5	0.11	0.20	0.38	0.64
0.1	0.022	0.045	0.087	0.17



SOPHIA 4096B Dimensions

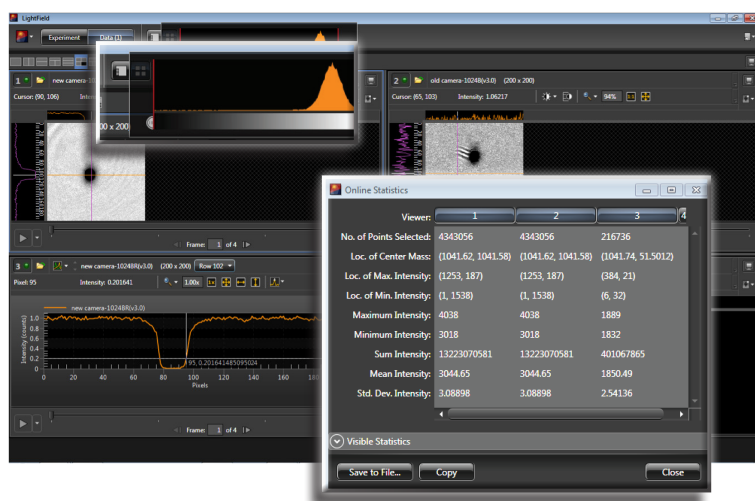


# LightField<sup>®</sup> Software

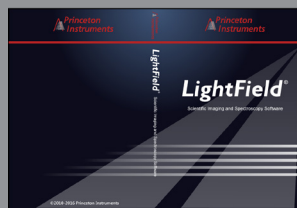
## The Future of Scientific Imaging and Spectroscopy Software

The combination of LightField and the SOPHIA 4096B provides researchers with the most advanced and reliable toolset for experimental setup, data acquisition, and post processing:

- ▶ Powerful 64-bit software package includes Microsoft Windows 10 support
- ▶ Complete control of Princeton Instruments cameras and spectrometers
- ▶ Dependable data integrity via automatic saving to disk, time stamping, and retention of both raw and corrected data
- ▶ Full experimental details and system settings are archived and can be reloaded for future experiments ensuring maximum reproducibility
- ▶ For light-sensitive experiments, the user interface offers “low light” and “no light” modes during data acquisition
- ▶ LightField works seamlessly in multi-user facilities, remembering each user’s hardware and software configurations
- ▶ Simple math functions and complex transforms can be applied to live or stored data, includes an easy-to-use editor to create your own formulas
- ▶ Integrated LabVIEW (National Instruments), MATLAB (MathWorks), ASCOM, Maxim DL (Cyanogen Imaging), and Python support
- ▶ Exports to your favorite file formats, including TIFF, FITS, ASCII, AVI, IGOR, and Origin
- ▶ Demo camera mode allows the user to view all of the settings and parameters associated with any camera without physically connecting the camera
- ▶ Live data processing operations provide real-time evaluation of incoming data to optimize experimental parameters



## The most comprehensive software support



Acclaimed LightField software for Microsoft Windows 10 (64 bit)



Seamless integration of controls and data acquisition into LabVIEW, MATLAB, ASCOM, Maxim DL, and Python



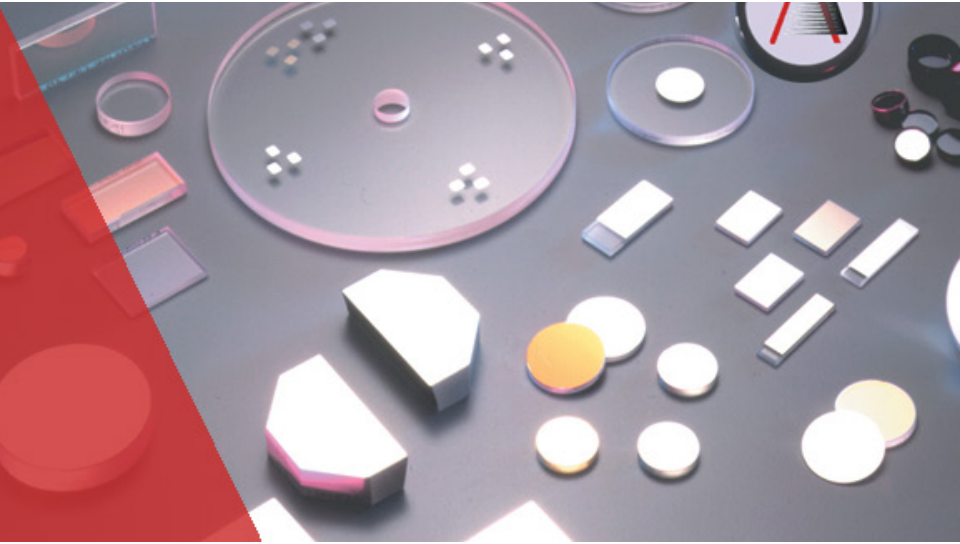
PICam software development kit (SDK) for Linux and Microsoft Windows

# Additional Optics & Coatings

In addition to advanced camera technology, Princeton Instruments provides the highest-performing optical components and optical subassemblies available for a diverse array of industries, including the medical, semiconductor, materials processing, analytic instrumentation, aerospace, and defense markets.

Since the 1960s, our Acton brand has become synonymous with the finest precision-engineered optics and coatings:

- ▶ UV laser optics
- ▶ Optical filters
- ▶ VUV / UV broadband optics
- ▶ CCD enhancement coatings
- ▶ Mirror blanks and windows



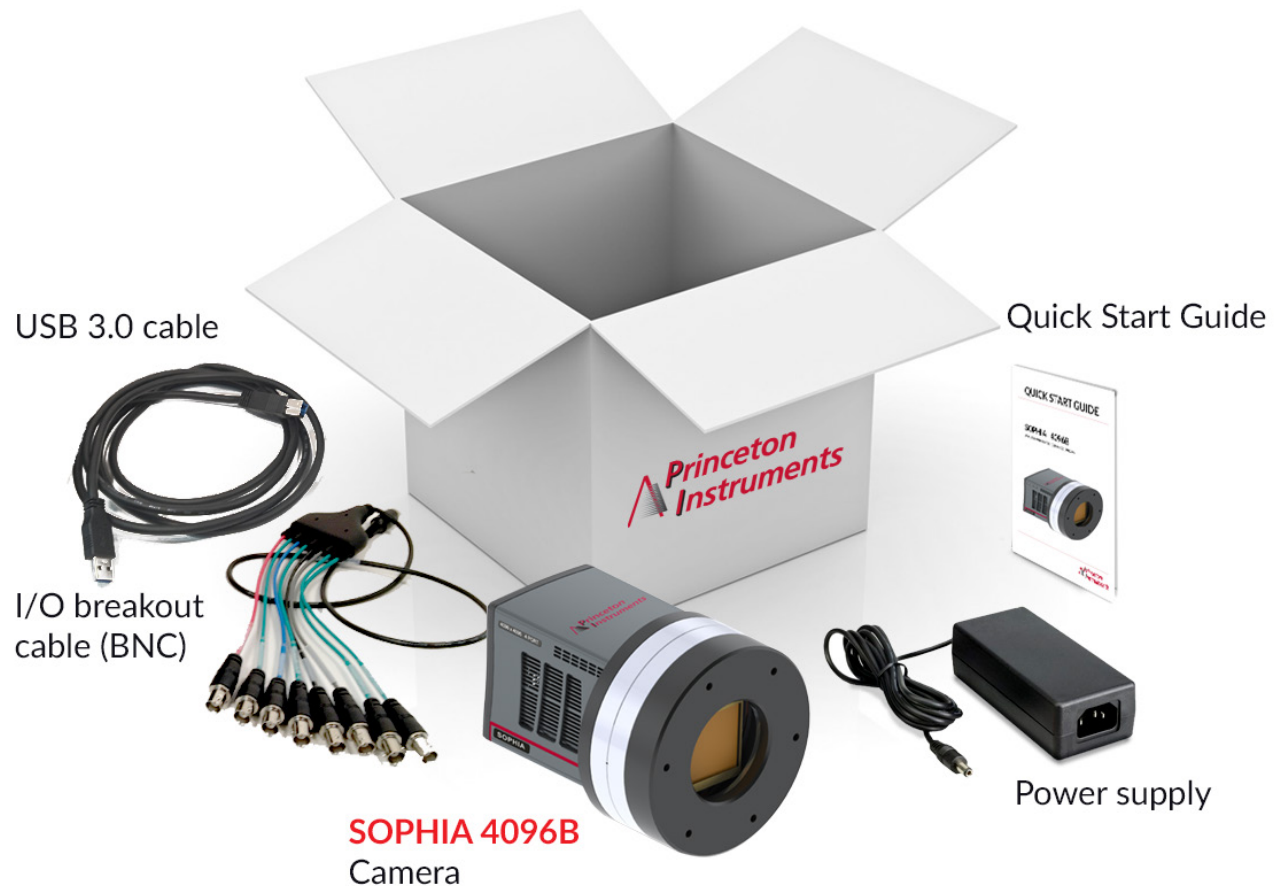
## Our core product competencies include:

- |   |                                  |
|---|----------------------------------|
| ▶ Excimer Laser Optics                      | ▶ UV Bandpass Filters            |
| ▶ Excimer Laser Mirrors                     | ▶ UV Rejection Filters           |
| ▶ Excimer Laser Beamsplitters               | ▶ Solar Blind Filters            |
| ▶ Femtosecond and Picosecond Laser Coatings | ▶ Solar Blue Filters             |
| ▶ Anti-Reflection Coatings                  | ▶ UV Reflective Filters          |
| ▶ UV Anti-Reflection Coatings               | ▶ Beamsplitters                  |
| ▶ Broadband Anti-Reflection Coatings        | ▶ UV Beamsplitters               |
| ▶ Narrowband Anti-Reflection Coatings       | ▶ Neutral Density Filters        |
| ▶ Aluminum Mirrors                          | ▶ UV Neutral Density Filters     |
| ▶ Silver Mirrors                            | ▶ CCD Enhancement Coatings       |
| ▶ Gold Mirrors                              | ▶ Lumogen Coatings               |
| ▶ Iridium Coatings                          | ▶ Metachrome® Coatings           |
| ▶ UV-Enhanced Mirrors                       | ▶ Filter Coatings on CCDs        |
| ▶ UV-Enhanced Silver Mirrors                | ▶ Optical Contract Manufacturing |
| ▶ Bandpass Filters                          |                                  |



# What is in the box?

SOPHIA 4096B cameras can be provided in custom configurations to suit your experiment. Please contact your local Princeton Instruments representative. The most common configurations are listed below:



## Optional accessories:

- LightField software
- PICam SDK/API for Linux and Microsoft Windows (provided for free)
- Liquid chiller
- Fiberoptic data extension cable for remote operation from up to 30 m

## Other CCD cameras from Princeton Instruments include:

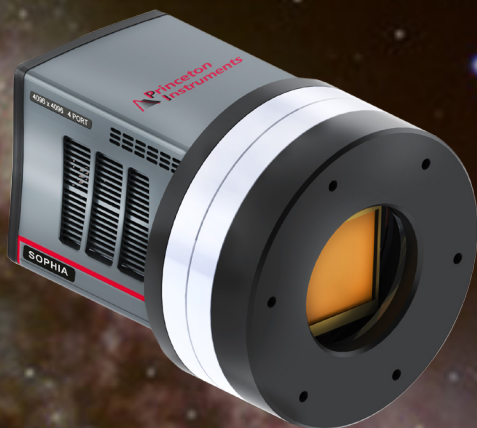
- **SOPHIA 2048B** – 2k x 2k version of SOPHIA large-format CCD cameras
- **SOPHIA-XO** – 2k x 2k and 4k x 4k soft x-ray direct-detection CCD cameras
- **NIRvana®** – Scientific-grade SWIR InGaAs cameras

Be sure to check out KURO™, the world's first back-illuminated 2k x 2k sCMOS cameras!



# SOPHIA 4096B

DEEP-COOLED, ULTRA-LARGE-FORMAT CCD CAMERAS



## Image Credits

Front cover and back cover:  
ESO

Page 8:  
Gravity waves and Milky Way image courtesy of Dr. Young-In Won, Korea  
Polar Research Institute.

SWIR angiography image courtesy of Dr. Oliver T. Bruns and Dr. Thomas  
S. Bischof, Bawendi Lab, MIT, Cambridge, MA, USA.

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