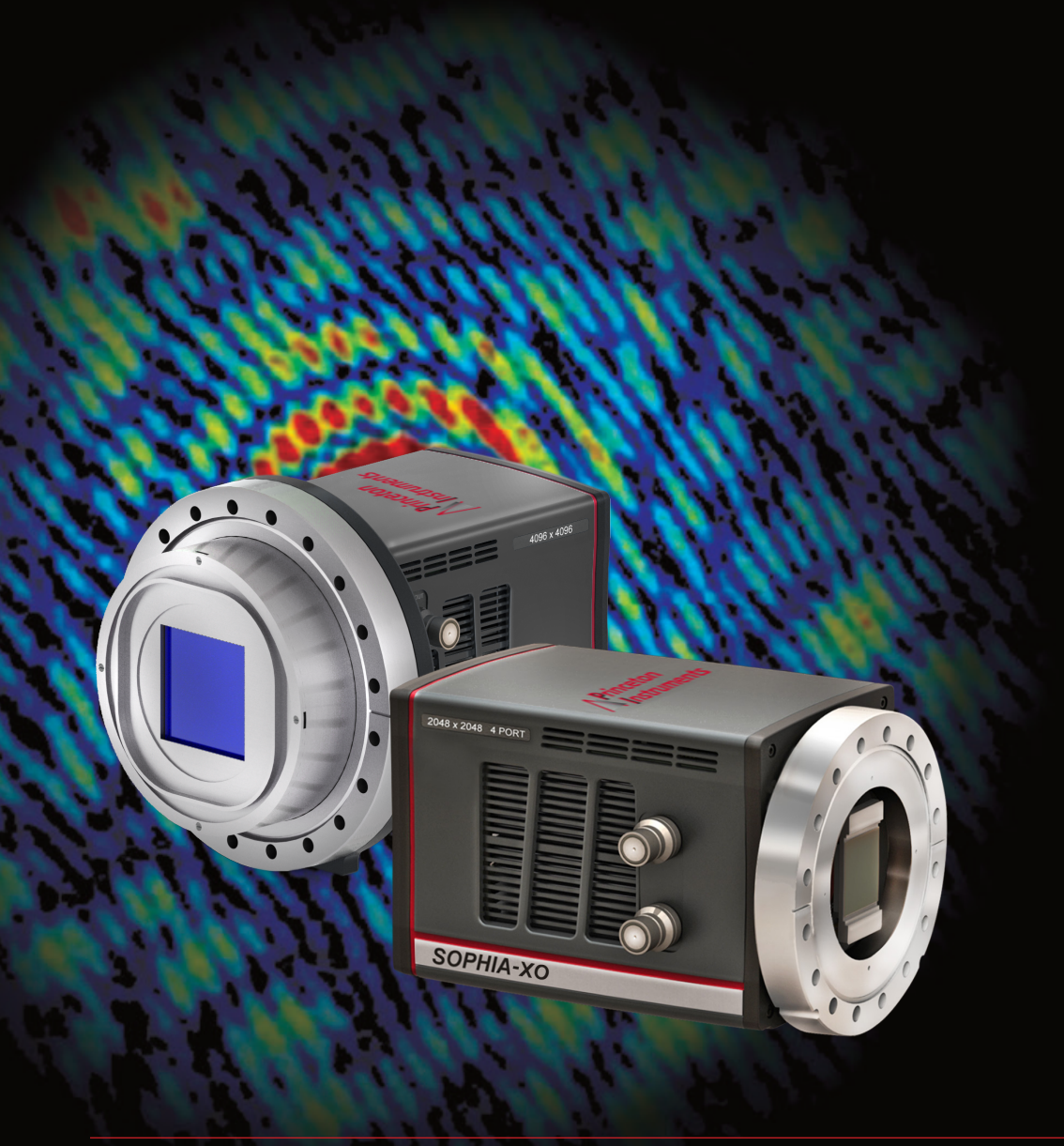
# SOPHIA®-XO 2048B
# SOPHIA®-XO 4096B

LARGE-FORMAT, DIRECT-DETECTION CCD CAMERAS FOR SOFT X-RAYS

## Datasheet




TELEDYNE
PRINCETON INSTRUMENTS
Everywhereyoulook™

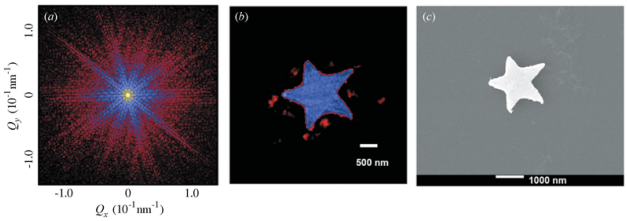
# Breakthrough Soft X-ray Performance


The SOPHIA-XO 2048B and 4096B represent the latest generation of EUV/VUV and soft x-ray direct-detection cameras:

- Back-illuminated CCD sensors with >95% QE (~5 eV to 30 keV range)
- 2k x 2k and 4k x 4k formats; 13.5 and 15 micron pixels
- High frame rates with up to 4-port readout
- Cooling down to -90ºC using liquid or air

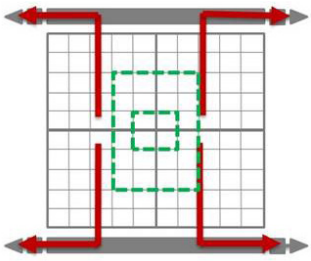
**Applications include:**
VUV/EUV/XUV Imaging | X-ray Diffraction | X-ray Microscopy | X-ray Holography | X-ray Spectroscopy | X-ray Plasma

## Princeton Instruments SOPHIA-XO soft x-ray cameras deliver speed, resolution, and sensitivity.



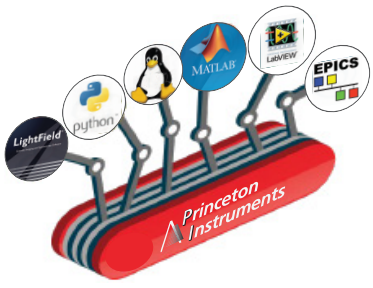

### Designed for low-flux applications...

SOPHIA-XO delivers optimum performance:
- Low read noise
- High QE (>95% peak)
- Wide dynamic range with up to 18-bit readout



### When speed is paramount...

SOPHIA-XO features the newest readout electronics:
- 1-, 2-, or 4-port simultaneous readout
- Multiple ADC speeds (up to 16 MHz)
- Binning and ROI readout
- Custom readout modes for microsecond exposures

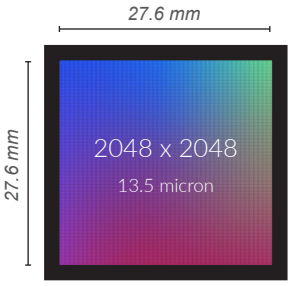



### We give you the most options!

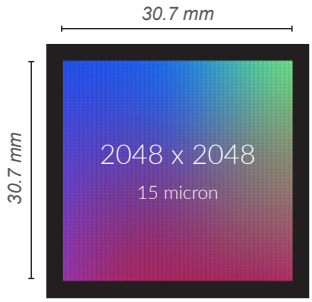
Most complex experiments require flexibility... SOPHIA-XO has what you need:
- Air or liquid cooling
- LightField with built-in math engine
- Microsoft® Windows® 10 or Linux® 64-bit operating system support
- Compatibility with Python®, Linux, MATLAB® (MathWorks), and LabVIEW® (National Instruments)
- Integration with EPICS software
- Rotatable flange for image alignment

# Key Camera Features

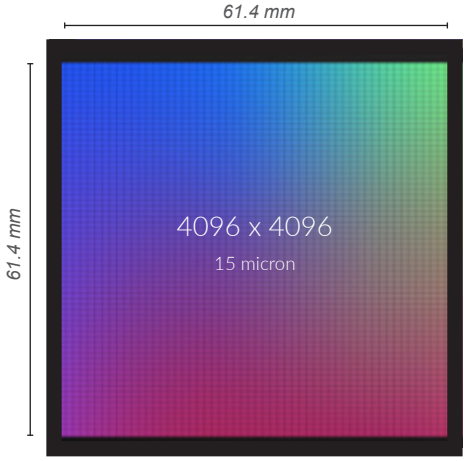
**SOPHIA-XO 2048B - 132**




**SOPHIA-XO 2048B - 152**

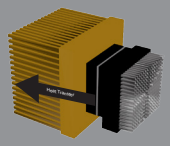



**SOPHIA-XO 4096B - 154**

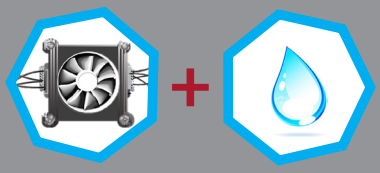



Large-format, back-illuminated 2048 x 2048 and 4096 x 4096 resolution CCD sensors with >95% peak quantum efficiency in the 5 eV to 30 keV range

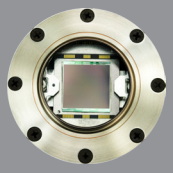
Proprietary 4-port readout for low noise and high frame rates



Ultra-high-vacuum, all-metal seal design for deep cooling (ArcTec™) down to -90ºC

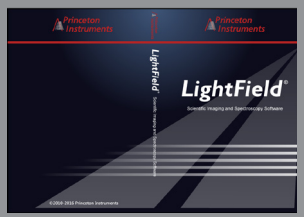


Flexibility to use air, air+liquid, or liquid cooling



The latest UHV technology with industry-standard CF flange vacuum interface (6 inch or 8 inch)

## The most comprehensive software support




Acclaimed LightField for Microsoft Windows 10 (64 bit)

EPICS

python

Compatible with EPICS and Python software

SDK

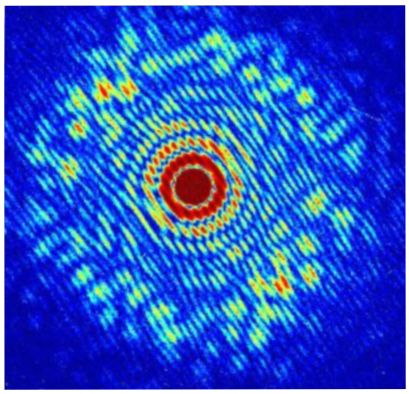
Windows

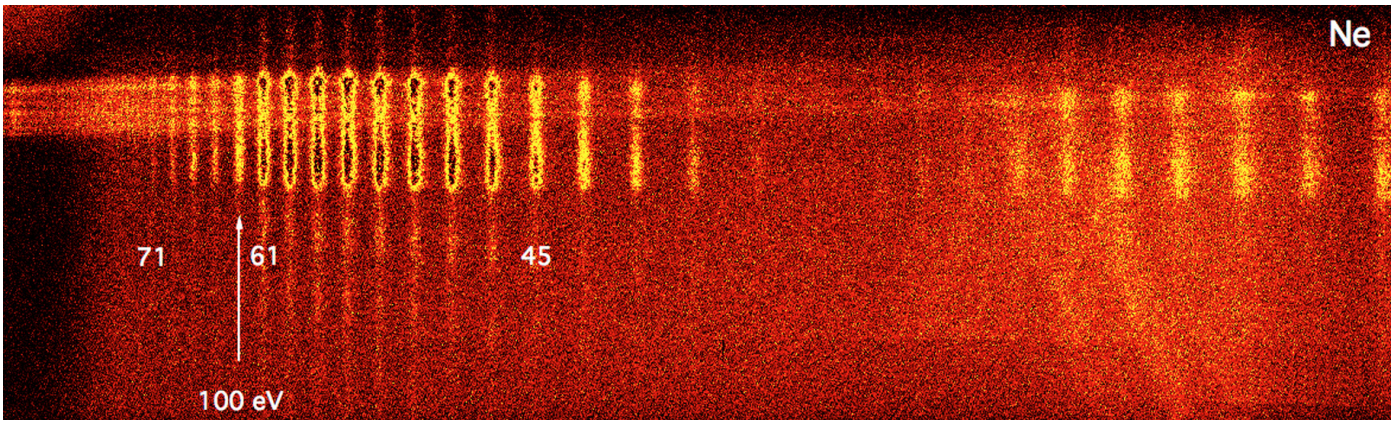
PICam software development kit (SDK) for Linux and Microsoft Windows

# Exceptional Reliability

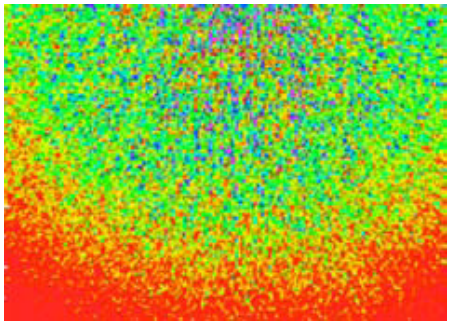
Princeton Instruments has been designing low-noise UV / x-ray detectors for more than three decades:

- Hundreds of cameras being used at leading laboratories around the world
- Years of trouble-free operation due to uncompromising engineering design and production
- Complete software ecosystem simplifies image acquisition and processing
- Continuous innovation to meet evolving requirements and applications






Princeton Instruments SOPHIA-XO soft x-ray cameras are the most advanced CCD detectors yet!

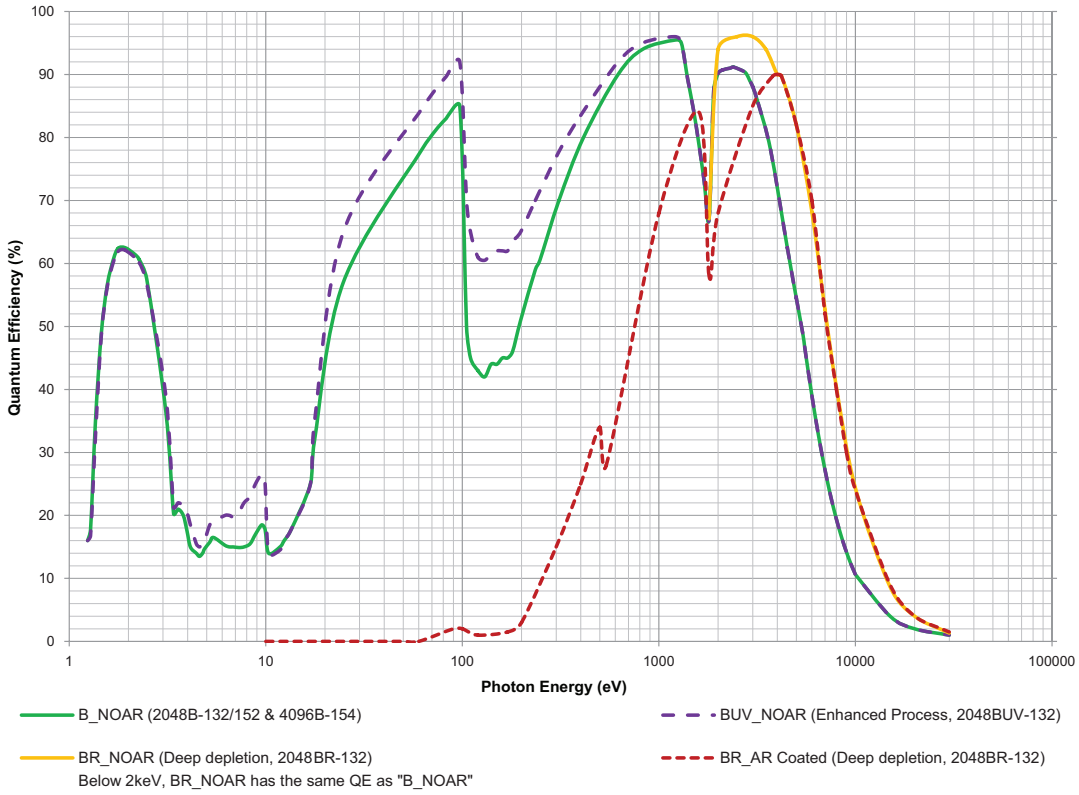


# SOPHIA-XO Specifications

| Feature | SOPHIA-XO 2048B - 132 | SOPHIA-XO 2048B - 152 | SOPHIA-XO 4096B - 154 |
|---|---|---|---|
| CCD image sensor | e2v CCD42-40; UV-enhanced grade 1; NIMO; back illuminated | e2v CCD230-42; scientific grade 1; AIMO; back illuminated; no AR coating | e2v CCD230-84; scientific grade 1; AIMO; back illuminated; no AR coating |
| CCD format | 2048 x 2048 imaging pixels; 13.5 x 13.5 µm pixels; 100% fill factor | 2048 x 2048 imaging pixels; 15.0 x 15.0 µm pixels; 100% fill factor | 4096 x 4096 imaging pixels; 15.0 x 15.0 µm pixels; 100% fill factor |
| Imaging area | 27.6 x 27.6 mm | 30.7 x 30.7 mm | 61.4 x 61.4 mm |
| Deepest cooling temperature (@ +20ºC) | < -90°C (typical) with liquid chiller; < -90°C (typical) with air | < -90°C (typical) with liquid chiller; < -90°C (typical) with air | < -80°C (typical) with liquid chiller; < -60°C (typical) with air |
| Thermostating precision | ±0.05°C | | |
| Dark current ($e^-$/pixel/sec) | 0.0001 | 0.00025 | 0.005 |
| Cooling method | Thermoelectric air or liquid cooling | | |
| Full well | Single pixel: 100 ke- (typical) | Single pixel: 150 ke- (typical) | Single pixel: 150 ke- (typical) |
| ADC speed | 8 MHz (4 MHz x 2 ports)<br>2 MHz (1 MHz x 2 ports)<br>200 kHz (100 kHz x 2 ports) | 16 MHz (4 MHz x 4 ports)<br>4 MHz (1 MHz x 4 ports)<br>400 kHz (100 kHz x 4 ports) | |
| ADC bits | 16 bits | 16 bits | 16 bits<br>18 bits @ 100 kHz and 1 MHz |
| System read noise | 3.5 e- rms @ 200 kHz<br>7.0 e- rms @ 2 MHz<br>19 e- rms @ 8 MHz | 3.6 e- rms @ 400 kHz<br>8.5 e- rms @ 4 MHz<br>22 e- rms @ 16 MHz | |
| Readout modes | 2-port or 1-port readout; Kinetics; External Sync | 4-port, 2-port, or 1-port readout; Kinetics; External Sync | |
| Nonlinearity | <2% @ 100 kHz | | |
| Software-selectable gains | 1, 2, 4 e-/ADU | | |
| Data interface | USB 3.0 (5 m interface cable provided);<br>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;<br>EPICS support via automation | | |
| Bake-out temperature | 70°C (maximum) | | |
| Vacuum compatibility | $10^{-8}$ Torr | | |
| Certification | CE | | |
| Operating environment | +5°C to +30°C non-condensing | | |
| Camera head dimensions (L x W x H) | DN100 or 6” industry-standard CF flange: 251.6 mm (9.91”) x 129 mm (5.08”) x 142.8 mm (5.62”) | DN100 or 6” industry-standard CF flange: 251.6 mm (9.91”) x 129 mm (5.08”) x 142.8 mm (5.62”) | DN160 or 8” industry-standard CF flange: 251.6 mm (9.91”) x 129 mm (5.08”) x 142.8 mm (5.62”) |

*Specifications are subject to change.*

# Quantum Efficiency Curves




# Frame Rates

**SOPHIA-XO 2048B - 132**

| Binning | 8 MHz | 2 MHz | 200 kHz |
|---|---|---|---|
| 1 x 1 | 1.35 | 0.43 | 0.05 |
| 2 x 2 | 2.82 | 1.34 | 0.18 |
| 4 x 4 | 3.76 | 2.82 | 0.65 |
| 8 x 8 | 4.30 | 3.76 | 1.82 |

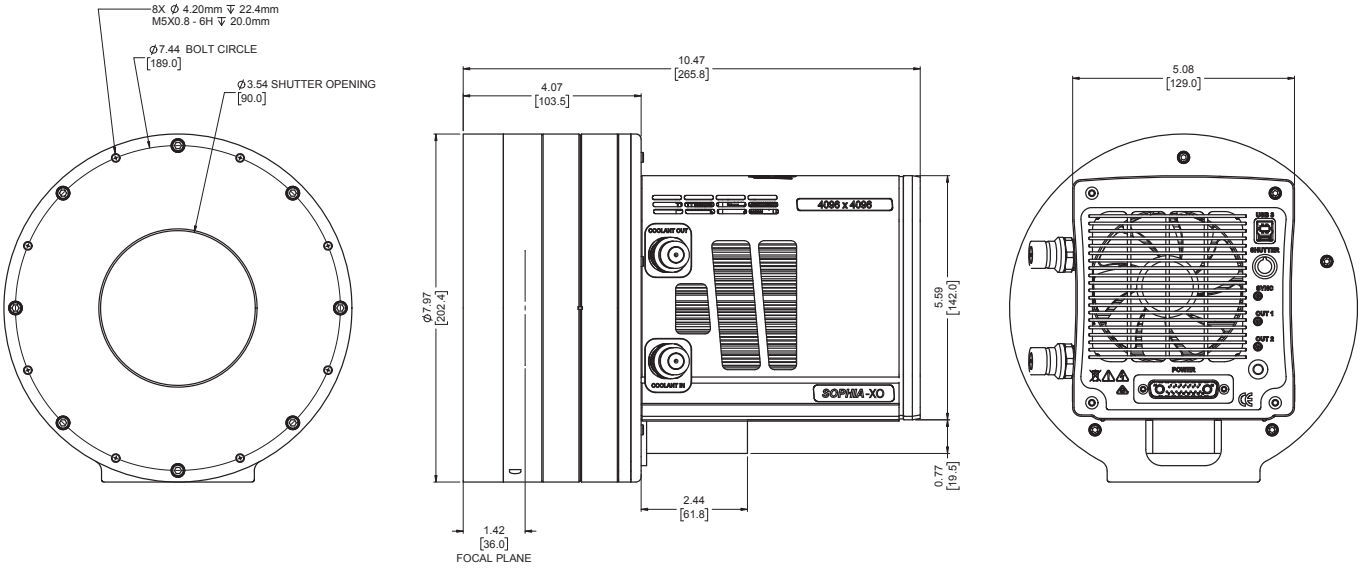
**SOPHIA-XO 2048B - 152**

| Binning | 16 MHz | 4 MHz | 400 kHz |
|---|---|---|---|
| 1 x 1 | 3.2 | 0.9 | 0.09 |
| 2 x 2 | 7.4 | 2.9 | 0.33 |
| 4 x 4 | 14.3 | 7.7 | 1.05 |
| 8 x 8 | 22.2 | 15.4 | 2.9 |

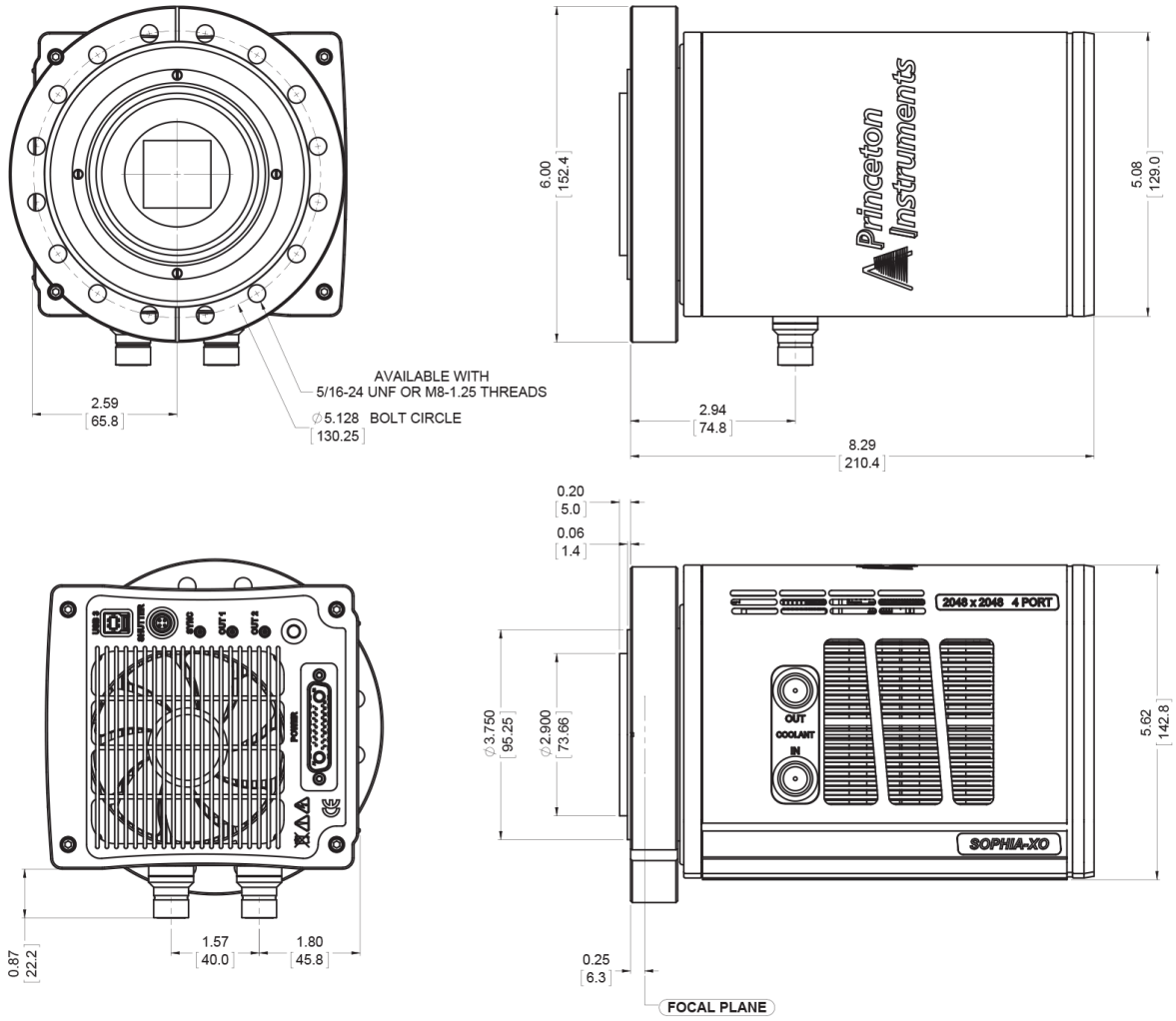
**SOPHIA-XO 4096B - 154**

| Binning | 16 MHz | 4 MHz | 400 kHz |
|---|---|---|---|
| 1 x 1 | 0.84 | 0.23 | 0.024 |
| 2 x 2 | 1.93 | 0.813 | 0.082 |
| 4 x 4 | 3.68 | 2.17 | 0.258 |
| 8 x 8 | 5.68 | 4.37 | 0.700 |

## SOPHIA-XO 4096B




## SOPHIA-XO 2048B

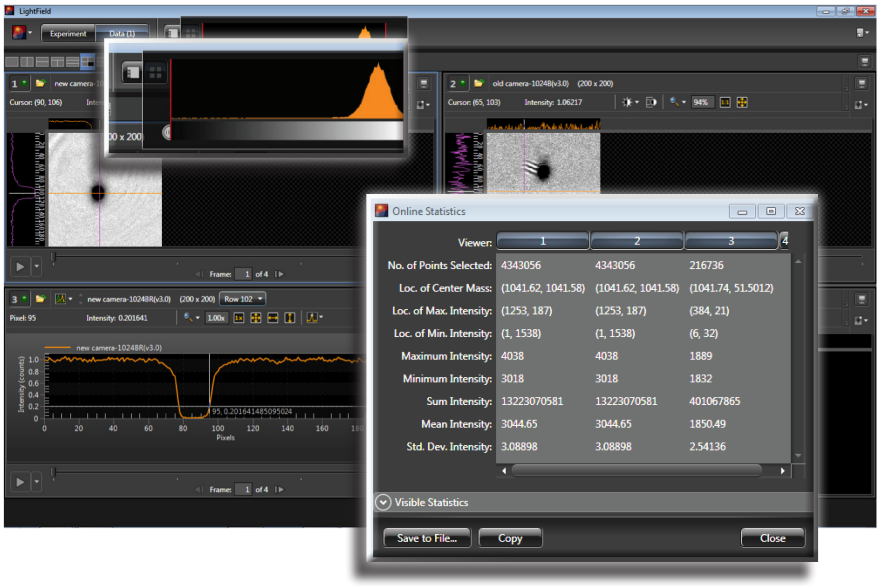


# LightField® Software

## The Future of Scientific Imaging and Spectroscopy Software

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

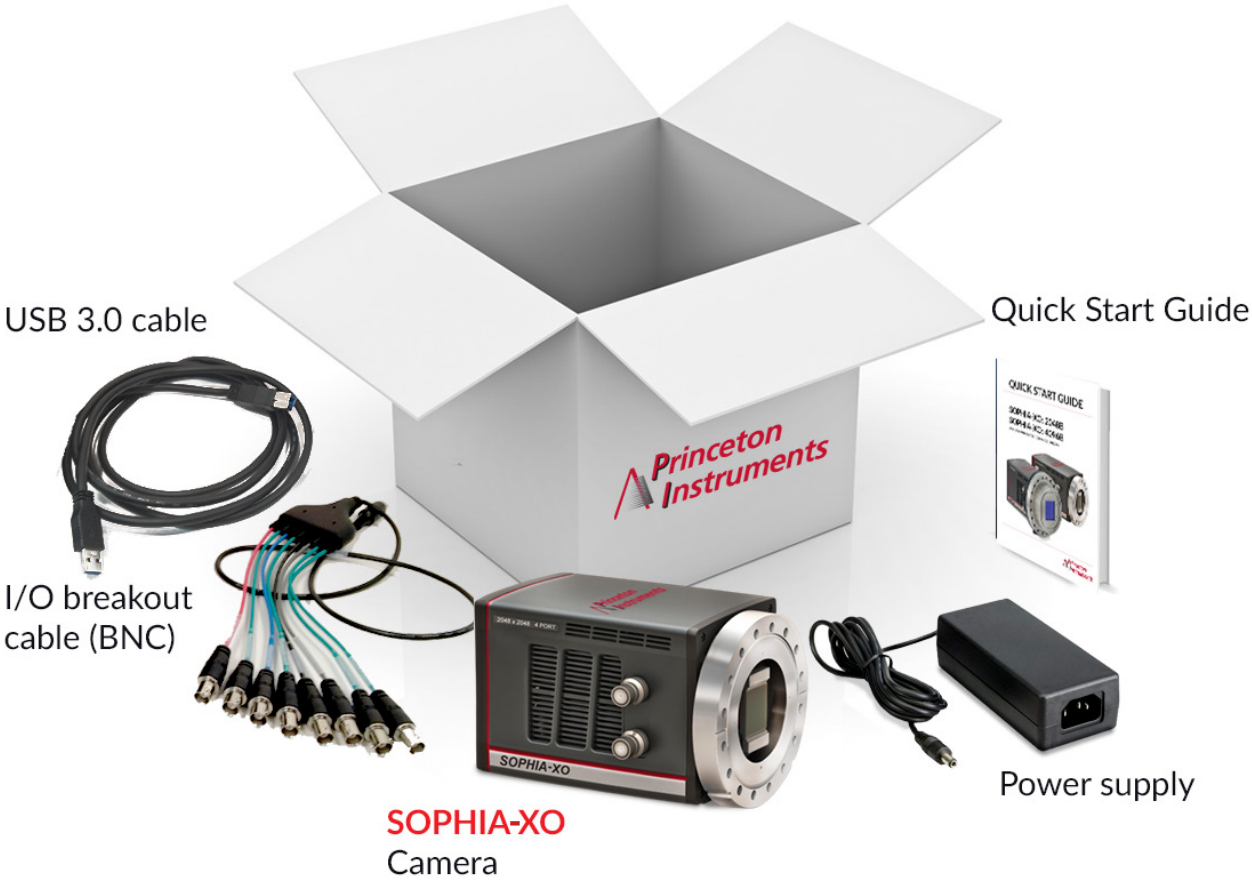
- Powerful 64-bit software package includes Microsoft Windows 10 support
- Complete control of Princeton Instruments cameras and spectrometers
- Dependable data integrity via automatic saving to disk, time stamping, and retention of both raw and corrected data
- Full experimental details and system settings 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), Python, and MATLAB (MathWorks) 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

# What is in the box?

SOPHIA-XO 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

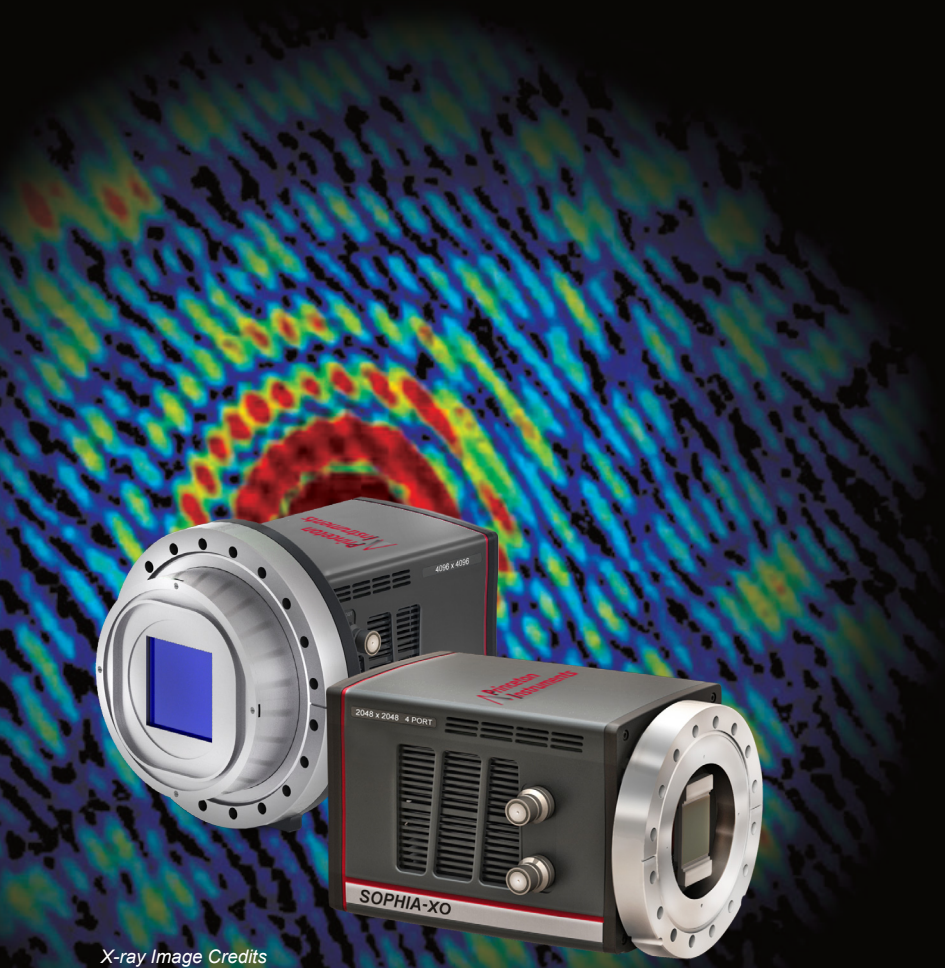
## Other x-ray cameras from Princeton Instruments:

- **PI-MTE & PI-MTE3** – Renowned “in-vacuum” cameras... now in 2k x 2k and 4k x 4k formats
- **PIXIS-XO** – Small-format 1k x 1k and 2k x 2k soft x-ray direct-detection cameras
- **PIXIS-XF & PIXIS-XB** – Fiber-coupled designs with 1k x 1k and 2k x 2k resolutions

Be sure to check out KURO™ (the world’s first back-illuminated sCMOS cameras) and SOPHIA (high-sensitivity CCD cameras) for UV-NIR imaging.

# SOPHIA-XO 2048B
# SOPHIA-XO 4096B

LARGE-FORMAT, DIRECT-DETECTION CCD CAMERAS FOR SOFT X-RAYS




*X-ray Image Credits*

*Front cover, page 4 (upper right), and back cover:*
*Dr. Jan Luning, SLAC*

*Page 2:*
*Yu et al., "Coherent X-ray scattering beamline at port 9C of Pohang Light Source II," J. Synchrotron Rad. 21, 264-267 (2014). doi: 10.1107/S1600577513025629*

*Page 4:*
*(center) Prof. Jens Biegert and Stephan Teichmann, The Institute of Photonic Science, Attoscience and Ultrafast Optics, Barcelona, Spain*
*(lower right) Dr. Jianwei Miao, UCLA*

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