

Marana-X

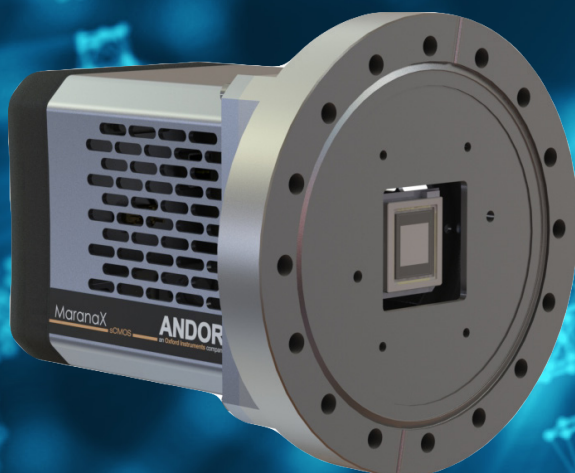
The Fastest sCMOS Camera for
Direct EUV and Soft X-ray Detection

Key Specifications

- ✓ High Resolution: 4.2 Megapixel
- ✓ High Sensitivity: Up to 99% QE
- ✓ Fast Speeds: Up to 74 fps
- ✓ High Dynamic Range: Up to 16-bit
- ✓ EMP Resistant: CoaXPress data interface
- ✓ Deep Cooled: -45°C cooling
- ✓ No mechanical shutter required

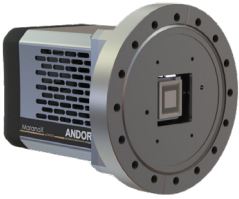
Key Applications

- ✓ *In situ* Radiography
- ✓ Tomography
- ✓ Spectroscopy
- ✓ Hyperspectral Imaging
- ✓ HHG Source Characterisation
- ✓ EUV Ptychography
- ✓ EUV Lithography



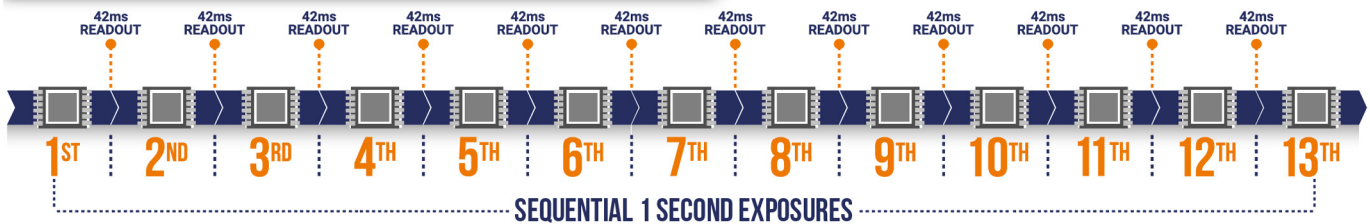
Introducing Marana-X

The Most Sensitive Back-illuminated sCMOS



Marana-X is Andor's ground breaking sCMOS platform tailored to direct EUV and soft X-ray applications. Hand crafted to deliver market leading performance and versatility Marana-X reads out a 4.2 Megapixel high resolution array in less than 50 milliseconds while maintaining very low read noise; hundreds of times faster than similar resolution CCD detectors.

Marana 2k x 2k sCMOS - 'low noise readout'

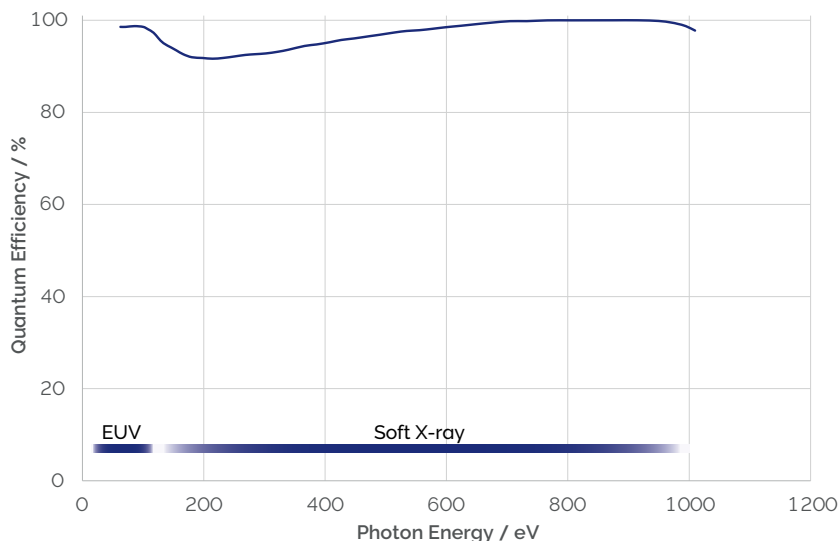


2k x 2k CCD (4 output ports) - 'low noise readout'



Unparalleled Quantum Efficiency

The **new** Marana-X sCMOS boasts superior quantum efficiency in the EUV-1 keV energy range compared to existing CCDs. The excellent quantum efficiency of the Marana-X complements its high end scientific CMOS technology allowing the minimisation of experimental time and maximum data throughput with a rapid 74 fps full frame. Additionally, the sensor quantum efficiency and life time of the Marana-X has been fully characterised in a recent scientific publication by [Harada and coworkers](#).

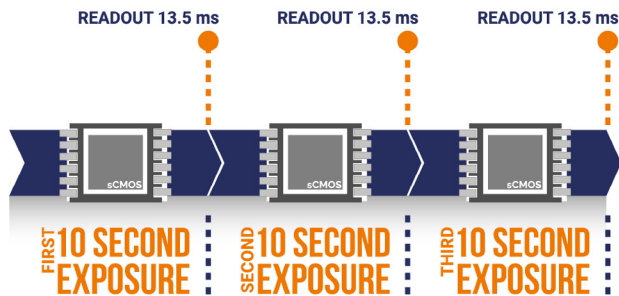


Features and Benefits

From soft X-ray tomography to hyperspectral imaging the Marana-X combines the sensitivity, speed, resolution and field of view to take on the most demanding imaging or spectroscopic challenges.

Feature	Benefit ^{*1}
Up to 99% QE & lowest noise	Maximum signal to noise for light starved measurements. Achieve high contrast faster.
Vacuum cooled to -45°C	Very weak signals require lowest noise floor and longer exposures: Don't be restricted by camera thermal noise!
4.2 Megapixel	High pixel resolution, maintaining image clarity over an extended field of view.
The ONLY uncoated back-illuminated sCMOS	The Marana-X incorporated the world's first uncoated back-illuminated sCMOS sensor enabling unparalleled EUV – soft X-ray detection.
Extended Dynamic Range (EDR) Mode	'One snap quantification' across the full dynamic range, capture high and low intensity images in the same image.
> 99.7% linearity	Market leading quantitative accuracy over the whole signal range.
Fan and liquid cooling as standard	Liquid cooling for maximum sensitivity.
Marana-X 4.2B-6^{*1}	
6.5 µm pixels	Smaller pixels better suited to some optical systems.
USB 3.0 and CoaXPress connectivity options	USB 3.0 provides flexibility. CoaXPress enables the highest speeds to capture the most dynamic events, and EMP resistant data transfer.
Low Noise Mode	Further reduces read noise floor at expense of pixel well depth, while maintaining a fast frame rate. Ideal when highest possible sensitivity is a priority.
High Speed Mode	Acquire images at high speeds of up to 74 fps in full frame 16-bit mode via CoaXPress! Boost speeds even further using regions of interest.
Superfast Spectroscopy Ready	On-head vertical pixel binning, ideal for dynamic spectroscopy (up to >25,000 spectra/sec).

Key Features

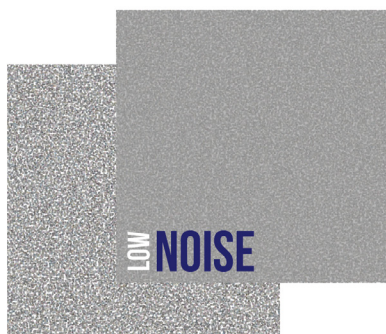


Fast Sensor Readout

Taking only 13.5 milliseconds per full frame readout, Marana-X can achieve a rapid 74 fps. Marana-X is ideal for the acquisition of large imaging data sets such as tomography and in-situ transient phenomena.

Extended Dynamic Range

Large pixel well-depth and an on-chip multi-amplifier design means the whole photometric range, from the noise floor up to the saturation limit, can be captured with one image. The wide dynamic range is complemented by enhanced on-head intelligence to deliver linearity > 99.7%, for unparalleled quantitative accuracy of measurement across the full signal range. Such capability is ideal for photometric accuracy of light curve measurements across a wide range of magnitudes.

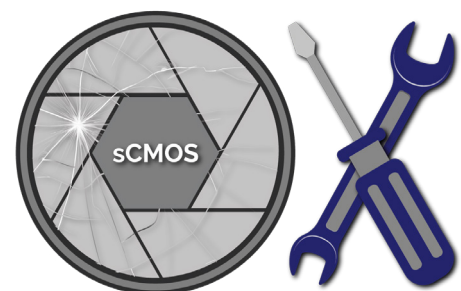


Low Noise

The uniquely optimised sensor of the Marana-X sCMOS enable peak quantum efficiency's in the EUV/soft X-ray regime of >99%. The parallel readout architecture and innovative pixel design enable Marana-X to drive exceptionally low read noise performance, <2 e⁻, while still achieving maximum readout speed and full dynamic range. Marana-X offers a further low noise mode to achieve 1.2e⁻ noise at reduced pixel well depth – ideal for extremely low flux applications.

No Mechanical Shutter

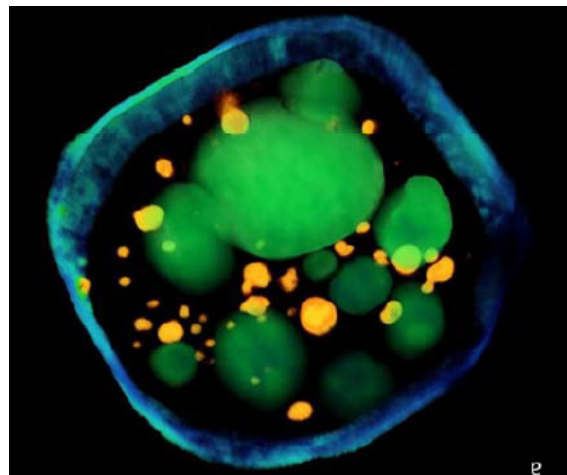
Applications that involve frequent cycling of mechanical shutters such as X-ray tomography, require routine shutter replacements and associated down time. Marana-X offers on-sensor Rolling Shutter thus overcomes the need for mechanical shutters. Furthermore, this avoids the exposure gradient effects associated with that of an iris shutter.



Application Focus

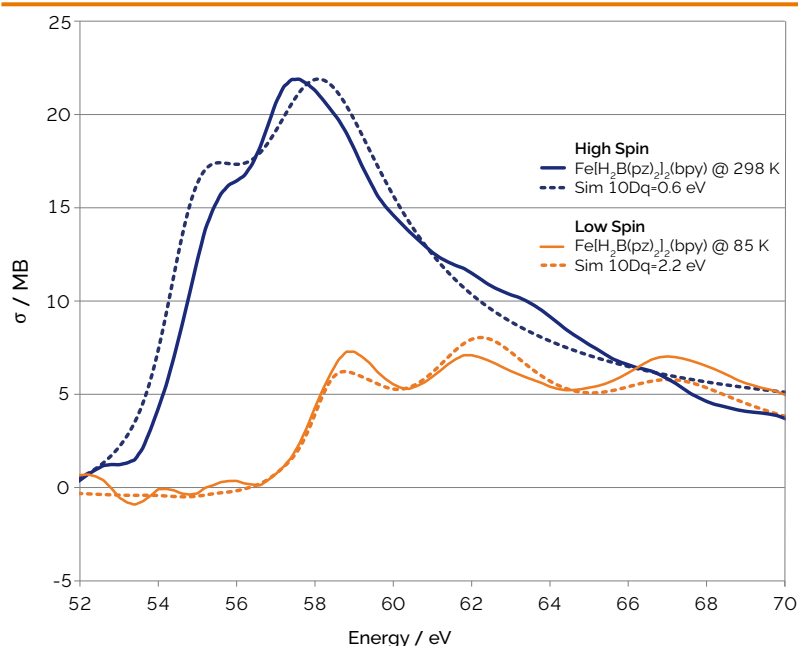
Soft X-ray Water Window Tomography

Soft X-ray microscopy in the water window (~285–535 eV) enables the unique imaging of intact cellular samples in their near-native state to resolutions of only a few 10s of nm in detail. The excellent speed of the Marana-X combined with unparalleled quantum efficiency in the 285–535 eV energy range makes the Marana-X the ideal camera for water window tomography. This coupled with low read noise and lack of mechanical shutter enables Marana-X to collect high contrast data sets with minimal experimental downtime.



Fogelqvist, E., Kördel, M., Carannante, V. et al. Laboratory cryo x-ray microscopy for 3D cell imaging. *Sci Rep* 7, 13433 (2017). <https://doi.org/10.1038/s41598-017-13538-2>

Soft X-ray Absorption Spectroscopy

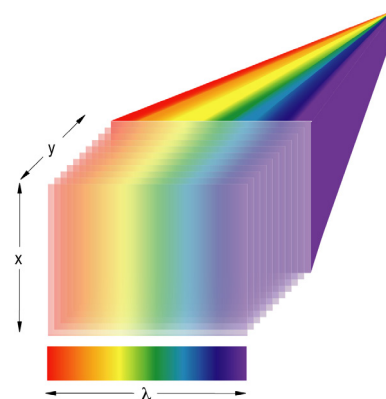


X-ray absorption near edge structure (XANES) is a powerful tool in the investigation of inner shell excitation. The unparalleled quantum efficiency in the soft X-ray regime of Marana-X makes it ideal for high harmonic generated femtosecond XANES experiments. The high frame rate of the Marana-X also enables it to match modern high repetition rate pulses frame for frame, maximising data collection and minimising experimental downtime.

Left: data from Kaili Zhang, Ryan Ash, Gregory S. Girolami, and Josh Vura-Weis, *Journal of the American Chemical Society* 2019 141 (43), 17180–17188, DOI: 10.1021/jacs.9b07332

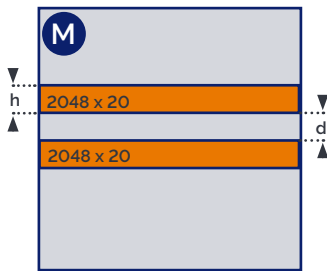
Hyperspectral

Marana-X is ideal for fast, high dynamic range spectral imaging, either: (a) hyperspectral configurations (push-broom or otherwise), enabling full data cubes to be rapidly acquired, or (b) high density multi-track spectroscopy at fast spectral rates and/or very high dynamic range through image stacking. For example, Marana-X can acquire 10 spectral tracks at almost 1500 fps, and can acquire a single spectrum at up to 25,000 fps.



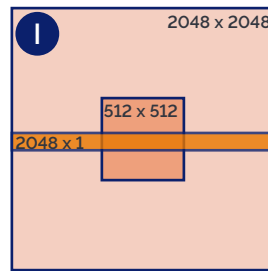
Modes for Marana

Multi-track Mode



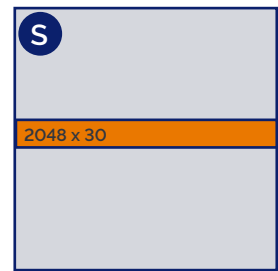
Up to 256 vertically binned tracks can be used for multi-track analysis without sacrificing speed.

Imaging Mode



The array size may be defined for either resolution or maximum speed.

Spectroscopy Mode



A vertically binned track is centred on the sensor enabling the maximum spectral rate to capture dynamic events.

M Multi-track Mode 4.2B-6

Vertically binned tracks (overlap ON)

Number of Tracks	Track height (h)		Track separation (d)		Max Acquisition Rate	
	Pixels	µm	Pixels	µm	16-bit	12-bit (Low Noise)
2	10	65	10	65	6887	4058
2	10	65	0	0	6887	4058
2	20	130	10	65	3608	2126
6	50	325	40	260	502	296
10	10	65	0	0	1485	875
10	20	130	0	0	750	442
10	30	195	30	195	502	296
50	20	130	0	0	151	89
60	20	130	0	0	126	74
100	20	130	0	0	76	45

I Imaging Mode 4.2B-6

Frame rate table

ROI Size (W x H)	Max Frame Rate (fps)				ROI area (of sensor)
	USB 3.0		CoaXPress		
	16-bit	12-bit (Low Noise)	16-bit	12-bit (Low Noise)	
2048x2048	40	43	74	44	13.3 mm x 13.3 mm
1400x1400	85	63	108	64	9.1 mm x 9.1 mm
1200x1200	116	74	126	74	7.8 mm x 7.8 mm
1024x1024	148	87	148	87	6.7 mm x 6.7 mm
512x512	295	174	295	174	3.3 mm x 3.3 mm
256x256	587	346	587	346	1.7 mm x 1.7 mm
128x128	1165	686	1166	687	0.8 mm x 0.8 mm

Modes for Marana Continued



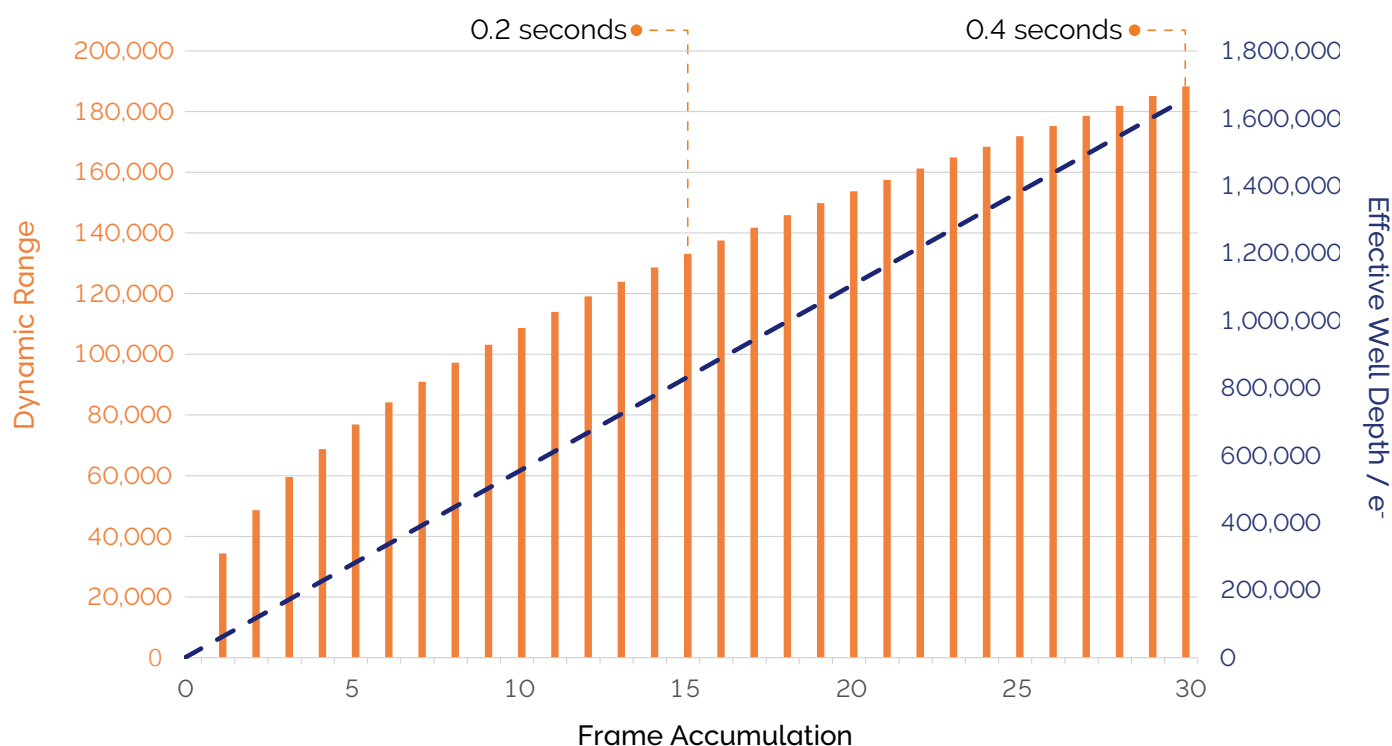
Spectroscopy Mode 4.2B-6

Vertically binned tracks (overlap ON)

Array Size (W x H)	Max Spectra Rate	
	16-bit	12-bit (Low Noise)
any x 1	25253	14881
any x 2	25253	14881
any x 8	15152	8929
any x 1200	126	74
any x 2048	74	44

Note: Frame/spectral rates do not differ if partial or full rows are selected.

Extend Dynamic Range - Fast Image Stacking



Dynamic Range and Effective Well Depth as a function of the number of stacked (accumulated) frames, plotted for Marana-X 4.2B-6. A Dynamic Range of 188,280:1, and a corresponding Effective Well Depth of 1,650,000 electrons can be reached with only 30 stacked frames. At maximum frame rate, this number of accumulated frames takes only 0.4 secs to acquire, achieving > 2 fps. This capability is significant for a range of challenges across imaging and spectroscopic characterisations.

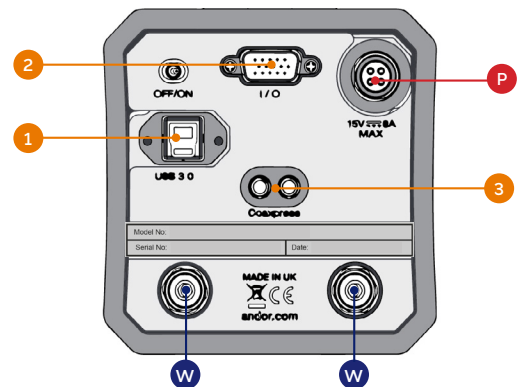
Technical Specifications¹

Model	Marana-X 4.2B-6
Sensor Type	Back-Illuminated Scientific CMOS
Array Size	2048 (W) x 2048 (H) 4.2 Megapixel
Pixel Size	6.5 x 6.5 μm
Image Area	13.3 mm x 13.3 mm (18.8 mm diagonal)
Readout Modes	Rolling Shutter
Pixel Readout Rates	310 MHz (Fast High Dynamic Range mode, 16-bit) 180 MHz (Low Noise mode, 12-bit)
Quantum Efficiency ²	up to 99%
Read Noise (e-) median ³	1.6 e- (Fast High Dynamic Range mode, 16-bit) 1.2 e- (Low Noise mode, 12-bit)
Sensor operating temperature ⁴ Air cooled Water/liquid cooled	-25°C (up to 30°C ambient) -45°C (@16°C water)
Dark Current Air cooled (@-25°C) Water/liquid cooled (@ -45°C)	0.15 e-/pixel/s 0.10 e-/pixel/s
Active area pixel well depth	55 000 e- (Fast High Dynamic Range mode, 16-bit) 1800 e- (Low Noise mode, 12-bit, bit depth limited)
Dynamic Range	34 000:1 (Fast High Dynamic Range mode, 16-bit)
Data Range	16-bit (Fast High Dynamic Range mode) 12-bit (Low Noise mode)
Linearity ⁵	> 99.7%
PRNU	< 0.5% (@ half-light range)
Region of Interest (ROI)	User-definable, 1 pixel granularity, min. size 9 (w) x 1 (h)
Pre-defined ROI	1608 x 1608, 1200 x 1200, 1024 x 1024, 512 x 512, 128 x 128
Pixel Binning (on FPGA)	2 x 2, 3 x 3, 4 x 4, 8 x 8 (user-definable binning also available)
I/O	O: Fire Row 1, Fire Row n, Fire All, Fire Any, Arm I: External
Trigger Modes	Internal, External, External Start, External Exposure, Software
Software Exposure Events ⁶	Start exposure - End exposure (row 1), Start exposure - End exposure (row n)
Image Timestamp Accuracy	25 ns
PC Interface	USB 3.0 ⁷ and CoaXPress
Mounting Flange	DN100CF (ConFlat) 6" O.D. fixed flange available with M8 or 5/16 UNC threaded holes

Flexible Connectivity

- 1** USB 3.0⁷
A convenient, universally available high speed interface.
- 2** TTL / Logic
Connector type: 15-way D-type to BNC cable with AUX_OUT_1 (Output), External Trigger (Input), ARM (Output).
- 3** CoaXPress
CoaXPress (2 lane) offers the highest speed data interface
- W** Water Cooling
Connection to recirculator or other water/liquid cooling system is possible for maximum sensitivity.
- P** Power
Connection to PSU refer to power requirements on page 12.

Notes: Minimum cable clearance required at rear of camera:
100 mm.



Best Practice Guidelines

Condensation

- It is strongly advised that the camera should not be used in a condensing atmosphere.
- If used in a condensing atmosphere the sensor MUST be protected and the use of a cold finger is strongly recommended.

Contamination & Damage

- When not in use, the sensor chamber should be covered and sealed.
- Due to the exposed nature of the sensor, extreme care should be taken with the camera, as damage can easily occur through mishandling or by contamination.
- If the sensor becomes contaminated, due to accident or misuse, please contact Andor immediately for advice on cleaning.

Vacuum Operations

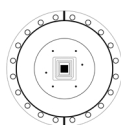
- Ensure that the vacuum environment to which the camera is fitted is free of water vapour and other contaminants.
- Care should also be taken to control pressure change, as sudden pressure changes can potentially cause damage to the sensor assembly.

Marana-X Purchase Flexibility

Don't want to commit to CoaXPress connectivity from the outset? If preferred, order the less expensive USB 3.0-only version and later avail of a simple in-field upgrade to CoaXPress capability, using the **CHAM-UPG-CXP** code, if and when additional speed is needed. The upgrade includes CoaXPress card, cable and remote session to upgrade camera firmware and unlock CoaXPress capability. Please contact your sales representative for more information.

Creating the Optimum Product for You

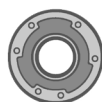
Step 1. Choose the camera type



Camera Type

Description	Code
Marana-X 4.2B-6: 4.2 Megapixel Back-illuminated sCMOS EUV/soft X-ray optimised, 6.5 µm pixel, >99% QE, 43 fps, USB 3.0 , 6" flange with 5/16 UNC threaded holes	MARANA-4BN6U-SOI
Marana-X 4.2B-6: 4.2 Megapixel Back-illuminated sCMOS EUV/soft X-ray optimised, 6.5 µm pixel, >99% QE, 74 fps, USB 3.0 & CoaXPress , 6" flange with 5/16 UNC threaded holes	MARANA-4BN6X-SOI
Marana-X 4.2B-6: 4.2 Megapixel Back-illuminated sCMOS EUV/soft X-ray optimised, 6.5 µm pixel, >99% QE, 43 fps, USB 3.0 , 6" flange with M8 threaded holes	MARANA-4BN6U-SOM
Marana-X 4.2B-6: 4.2 Megapixel Back-illuminated sCMOS EUV/soft X-ray optimised, 6.5 µm pixel, >99% QE, 74 fps, USB 3.0 & CoaXPress , 6" flange with M8 threaded holes	MARANA-4BN6X-SOM

Step 2. Select the required accessories



Accessories

Description	Order Code
Re-circulator for enhanced cooling performance (supplied with 2x2.5 m tubing as standard)	XW-RECR
Oasis 160 Ultra compact chiller unit (tubing to be ordered separately)	ACC-XW-CHIL-160
6 mm tubing options for Oasis 160 Ultra compact chiller (2x2.5 m or 2x5 m lengths)	ACC-6MM-TUBING-2X2.5 ACC-6MM-TUBING-2X5M
Pair of barbed hose inserts for 6 mm tubing	6MM-HOSE-BARBS
Beryllium filter for Marana-X (250 µm thick)	ACC-OPT-03838
Optional filter holder for Marana-X	SO-FILTER-MNT-IKONL

CSR

Other flange options are available through our CSR process - please contact your sales representative.

Step 3. Select the required software



Software

Marana-X requires one of the following software options:

Solis Imaging

A 32-bit and fully 64-bit enabled application for Windows (8, 8.1 and 10) offering rich functionality for data acquisition and processing. AndorBasic provides macro language control of data acquisition, processing, display and export.

Andor SDK3

A software development kit that allows you to control Andor sCMOS cameras from your own application. Available as a 32-bit or 64-bit library for Windows (8, 8.1 and 10) and Linux. Compatible with C/C++,

LabView and Matlab.

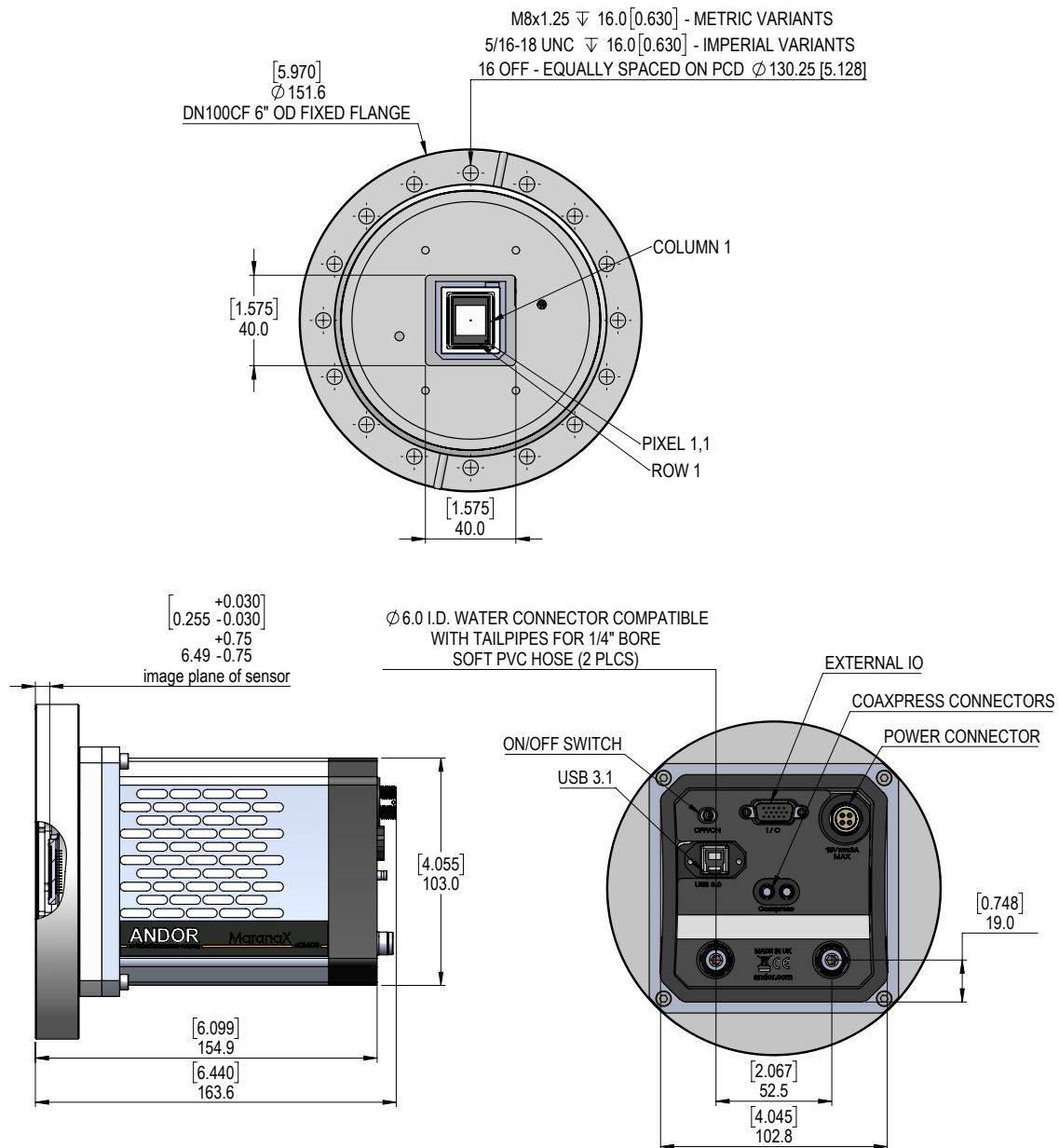
GPU Express Andor GPU Express library has been created to simplify and optimize data transfers from camera to a CUDA-enabled Nvidia Graphical Processing Unit (GPU) card to facilitate accelerated GPU processing as part of the acquisition pipeline. Integrates easily with Andor SDK3 for Windows.

Third party software compatibility Drivers are available for a variety of third party imaging packages. See Andor website for detail: <https://andor.oxinst.com/learning/view/article/third-party-imaging-software-support>

Mechanical Drawings

Dimensions in mm [inches]

Weight (approx): ~5.4 kg



Have you found what you are looking for?

Need a larger field of view? [iKon-XL CCD](#) offers a 16.8 Megapixel sensor with 15 µm pixel pitch offering up to 350 ke- well depths, 18 bit dynamic range and – 80°C deep cooling.

Need faster frame rates? The [Zyla-HF](#) fibre coupled to scintillator sCMOS platform can deliver 100 fps from a full 5.5 or 4.2 Megapixel array, faster still with sub-array selection.

Looking at hard X-rays or Neutrons? The [Bior-X sCMOS](#) offers a market leading 16.9 Megapixel sensor combined with rapid 54 fps full frame readout, high dynamic range and low noise readout ideal for lens coupled experimental setups.

Order Today

Need more information? At Andor we are committed to finding the correct solution for you. With a dedicated team of technical advisors, we are able to offer you one-to-one guidance and technical support on all Andor products.

For a full listing of our local sales offices, please see: andor.com/contact

Our regional headquarters are:

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China

Beijing
Phone +86 (10) 5884 7900
Fax +86 (10) 5884 7901

Items shipped with your camera

1x USB 3.0 PCIe card*7
1x USB 3.0 Cable (3 m)*7
1x Multi I/O Timing Cable (BNC to D-type: 1.5 m)
1x 15 V PSU
1x Country specific power cord
1x User manuals in electronic format
1x Quickstart Guide
1x Individual system performance booklet
Marana-X 4.2B-6 with CoaXPress also includes:
1x CoaXPress 3.0 PCIe card with external trigger
1x CoaXPress Cable (3 m)
1x Single I/O Timing Cable (BNC to SMB: 1.5 m)

Footnotes

- Figures are typical and target specifications and therefore subject to change.
- Quantum efficiency as supplied by the sensor manufacturer.
- Read noise measured at 0°C (Marana-X 4.2B-6).
- Coolant temperature must be above dew point.
- Linearity is measured from a plot of Signal vs. Exposure Time over the full dynamic range.
- Software Exposure Events provide rapid software notification (SDK only) of the start and end of acquisition.
- Marana-X connects to your control PC using a USB 3.0 connection. This may also be referred to as USB 3.1 (Gen 1). Andor provide a USB 3.0 card and cable, and recommend that these are used to ensure optimum performance.

andor.com

Minimum Computer Requirements:

- 3.0 GHz single core or 2.4 GHz dual or quad core processor
- 8 GB RAM
- Hard drive: 850 MB/sec write speed recommended for the data rate associated with the max. frame rates. 250 MB free hard disc to install software
- USB 3.0 slot (or x4 PCIe slot for USB 3.0 card)
- x8 PCIe slot for CXP PCIe card
- Windows (8, 8.1 and 10) or Linux

Operating & Storage Conditions:

- Operating Temperature: 0°C to +30°C ambient
- Operating Altitude: up to 6000 m
- Relative Humidity: <70% (non-condensing)
- Storage Temperature: -10°C to 50°C

Power Requirements:

- 100 - 240 VAC, 50 - 60 Hz
- Power consumption: 40 - 46 W typical / 114 W max (model dependent)



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Labview is a registered trademark of National Instruments.
Matlab is a registered trademark of The MathWorks Inc.