ANDOR
an **Oxford Instruments** company

iXon Ultra 888 NEW!

World's Fastest Megapixel Back-illuminated EMCCD

Features include:

Largest Field of View EMCCD

3x Faster

1 Megapixel

13 μm pixel size

Single Photon Sensitive

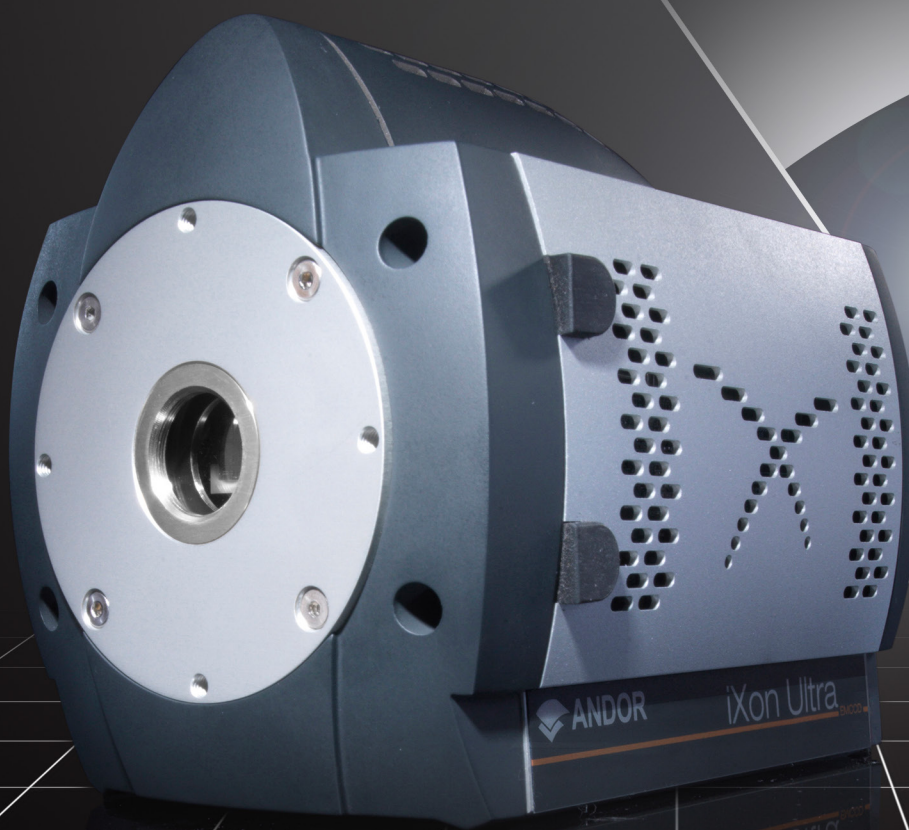> 90% QE

30 MHz

26 fps full frame

93 fps @ 512 x 512

USB 3.0

ANDOR iXon Ultra

FIELD OF VIEW & SENSITIVITY... NOW 3X FASTER!

The highly innovative iXon Ultra 888 megapixel, back-illuminated EMCCD camera offers single photon sensitivity across a large field of view, at 26 fps. Building on a rich history of first to market innovation, the 'supercharged' iXon Ultra 888, represents a massive performance boost for the largest available EMCCD sensor, as well as the first USB 3.0 enabled EMCCD camera.

The iXon Ultra 888 has been fundamentally re-engineered to facilitate a **3x acceleration** of the pixel readout speed to an unprecedented 30 MHz, whilst maintaining quantitative stability, propelling the full frame performance to **video rate**. Furthermore, Andor's unique **'Crop Mode'** can be employed to further boost frame rates from a user defined sub-region, for example pushing a 512 x 512 sub-array to 93 fps and a 128 x 128 area to **697 fps**.

With a **1024 x 1024 sensor format and 13 µm pixel size**, the resolving power, field of view and unparalleled speed of the iXon Ultra 888 render it the most attractive and versatile EMCCD option for demanding applications such as single molecule detection, super-resolution microscopy, live cell imaging and high time resolution astronomy.

The iXon Ultra is designed to be the most **flexible** yet **easy to use** EMCCD on the market, optimizable for a wide variety of application requirements in a single click via the OptAcquire™ feature. Furthermore, signal can be quantitatively calibrated in units of **electrons** or **photons**, either in real time or post-processing. Patented, pioneering technology offers **automated recalibration** of EM gain, alongside anti-ageing protection.

Crucially, the iXon brand carries an outstanding reputation within the industry for **quality** and **reliability**, brandishing an unparalleled track record of minimal field failures.

Key Specifications

Active pixels (H x V)	1024 x 1024
Pixel size (W x H; µm)	13 x 13
Image area (mm)	13.3 x 13.3
Active Area Pixel Well Depth (e$^-$)	80,000
Max Readout Rate (MHz)	30
Frame rates (fps)	26 (full frame) - 9690
Read noise (e$^-$)	<1 with EM gain
QE Max	>90%
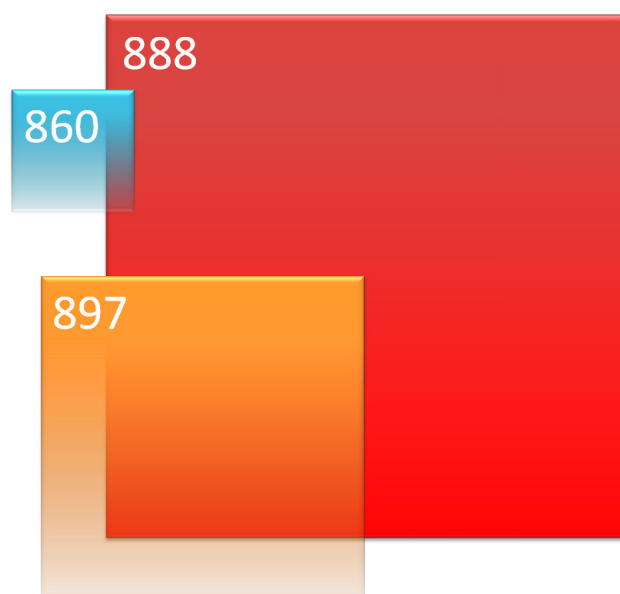
Relative sensor size of the iXon models:
888 (1024 x 1024); 897 (512 x 512); 860 (128 x 128)

FEATURES & BENEFITS

Overclocked to 30 MHz readout **NEW!**	Industry fastest frame rates; 26 fps full frame.
13.3 x 13.3 mm sensor	Largest field of view EMCCD available.
Optically Centred Crop Mode (live cell super-resolution)	Continuous imaging with fastest possible frame rate from centrally positioned ROIs; 251 fps from 256 x 256 ROI. Highly enabling for live cell super-resolution and much, more.
First USB 3.0 enabled EMCCD **NEW!**	Enhanced bandwidth and simple connectivity.
13 µm pixel size	Superb balance of resolving power and photon collection efficiency.
EX2 Technology (optional) **NEW!**	Extended QE response, beyond standard back-illuminated.
TE cooling to -95°C	Elimination of darkcurrent detection limit.
RealGain™	Absolute EMCCD gain selectable directly from a linear and quantitative scale.
Fringe Suppression (optional) **NEW!**	Reduced etaloning in NIR.
OptAcquire	Optimize the highly flexible iXon for different application requirements at the click of a button.
Count Convert	Quantitatively capture and view data in electrons or incident photons.Real time or post-processing.
EMCAL™	Patented user-initiated self-recalibration of EM gain.
iCam	Exposure time fast switching - market leading acquisition efficiency.
UltraVac™[1]	Maintain unequalled cooling and QE performance, year after year. 7 year vacuum warranty.
Spurious Noise Filter **NEW!**	Intelligent algorithms to filter clock induced charge events from the background. Real time or post-processing.
Direct Data Access	Camera Link output port to facilitate direct access to data for 'on the fly' processing.
Enhanced Photon Counting Modes	Intuitive single photon counting modes to overcome multiplicative noise. Real time or post-processing.
Superior Baseline Clamp and EM Stability	Quantitative accuracy of dynamic measurements.
Lower Noise CCD Mode **NEW!**	'2 in 1' flexibility. EMCCD for ultra-sensitivity at speed, conventional CCD for longer acquisitions.
FPGA Timestamp **NEW!**	Hardware generated timestamp with 10 ns accuracy.
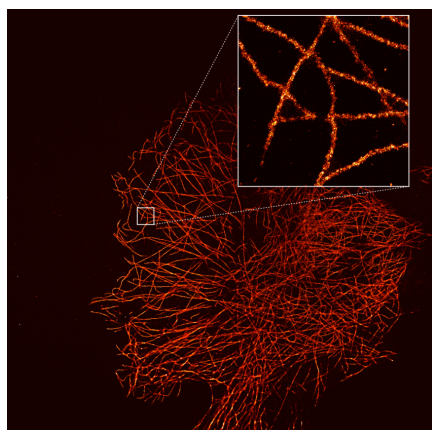
dSTORM image of U2OS cells showing microtubules stained with Alexa 647 antibody captured with the iXon Ultra 888. Courtesy of Alan Lowe and Ricardo Henriques, UCL, London, UK.

APPLICATION FOCUS

Choice of Disciplines

The Biologist's Choice

The iXon Ultra 888 is the most versatile, high performance EMCCD available; the enhanced FOV, excellent resolving power, superb sensitivity and market leading readout speed renders it adaptable to a host of uses in the biology/biophysics laboratory. In applications such as single molecule detection, super-resolution, microscopy live cell microscopy (including spinning disk confocal), calcium signalling, and transport/motile imaging, where weak, rapidly changing fluorescent signals from cells must be dynamically imaged, Andor's iXon Ultra 888 offers an ideal detection solution. Ultra-sensitive detection capability in fluorescence microscopy facilitates use of lower excitation powers (thereby reducing photobleaching and phototoxicity) and lower dye concentrations.

The Physicist's Choice

The unique high-performance specifications of the optimized iXon range have been serving the physical scientist and astronomer in scenarios that demand more than simply an EM sensor in a camera. Andor have worked with numerous scientists to deliver solutions that work for their particular application requirements, such as specific coatings, coupling to fibre optic scintillators and 'minimized latency' direct data access solutions.

Capture everything, large or small, fast or slow…

Extreme Sensitivity – capture, resolve and quantify extremely weak structures.

Capture More – the 13.3 x 13.3 mm sensor is well suited to the optically useful FOV from a microscope.

3x Faster – more and more studies of cell processes require greater temporal resolution. The Ultra 888 offers the fastest available EMCCD readout capability.

Superb Image Quality – megapixel resolution and uniform backgrounds for publication quality imaging.

Example Areas of Application

Single Molecule Detection

Andor's iXon EMCCD has long been the gold standard detector of the biophysics laboratory, and remains the dominant detector type, operating in a low light regime that is less suited to sCMOS cameras. The 3x accelerated 30 MHz readout speed of the iXon Ultra 888, especially combined with 'Optically Centred Crop Mode', means that dynamic single molecule processes can be better characterised. The 13 µm pixel provides superb resolving capability at the diffraction limit.

Super Resolution Microscopy

The iXon has proven extremely popular for single molecule based 'pointillist' super-resolution microscopy approaches (e.g. STORM, PALM). The speed-boosted Ultra 888 is an exceptional solution for Live Cell super-resolution, whereby 'Optically Centred Crop Mode' can be used to achieve up to 697 fps from a 128x128 sub-array. The superb image homogeneity and minimal blemish specification of an EMCCD sensor makes it the technology of choice for many research groups in this field.

Quantum Science

The Ultra 888 brings a large FOV high speed EMCCD camera to the Quantum world, with single photon sensitivity at 26 FPS full frame you can capture the weakest signal from a lattice array of atoms or use the optical centred crop mode and boost your frame rate to 697 fps for a 128X128 sub array to image the smallest single condensate. The camera is easily integrated into complex systems with accuracy down to 10 ns with FPGA time stamps.

Spinning disk confocal

The iXon Ultra 888 is the ideal detector to drive low light performance from the Yokogawa CSU-W1 confocal spinning disk, which offers a larger field of view and deeper imaging. See Andor's Revolution WD system for further details.

Physiology / Ion Imaging & Cell Motility

Unsurpassed EMCCD sensitivity and superb custom ROI speeds make the Ultra 888 the best possible detector for temporally resolving fast calcium sparks and waves under low dye concentrations, especially when combined with low light optical sectioning modalities. The same advantages play equally well to imaging of the motile cell.
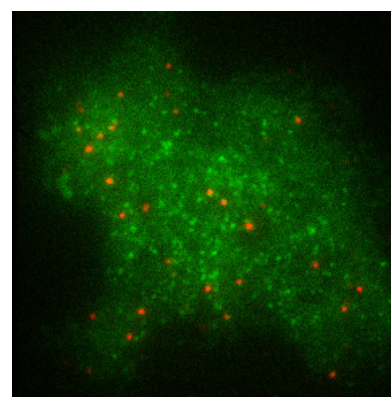
Fast Astronomy

Extremely fast and ultra-sensitive performance of binned sub-regions make this an ideal Shack Hartmann AO detector. The large FOV and fast frame rate are ideal for Lucky / Speckle Imaging.

Tomography

Lens coupled or customer fibre coupled, the iXon Ultra 888 provides the superlative ultrasensitive, large array solution for fast tomography

Luminescence

The Ultra 888 can be used in either single photon counting mode (EM amplifier) or in slow scan, deep cooled CCD mode (CCD amplifier) as a highly sensitive and flexible detector in this typically long exposure, extreme low light application.

TIRF image of TrpV1 channel (red) and clathrin (green) in a living HEK cell captured using the iXon 888 EMCCD and OptoSplit device to capture the two colours simultaneously.

Courtesy of Sanaz Sadegh and Prof. Diego Krapf, Colorado State University

EMCCD or sCMOS?

Since the market introduction of sCMOS technology by Andor, the question of the performance comparison against the more established Electron Multiplying CCD (EMCCD) has been a common one.

Being a very fast, low noise technology, sCMOS does hold some potential to offer an alternative technology across some applications and techniques, including to an extent, super-resolution microscopy and TIRF microscopy. Whilst the read noise of sCMOS is very low compared to CCDs, EMCCD technology holds the distinct advantage of being able to practically eliminate read noise, rendering them single photon sensitive.

After a few years of sCMOS being tested in the market, we are concluding that the primary light staved applications for which EMCCDs were originally purchased, such as single molecule detection and low light spinning disk confocal microscopy, are continuing to strongly benefit from this ultrasensitive technology. EMCCDs offer a raw sensitivity that cannot be surpassed in the very low light regime.
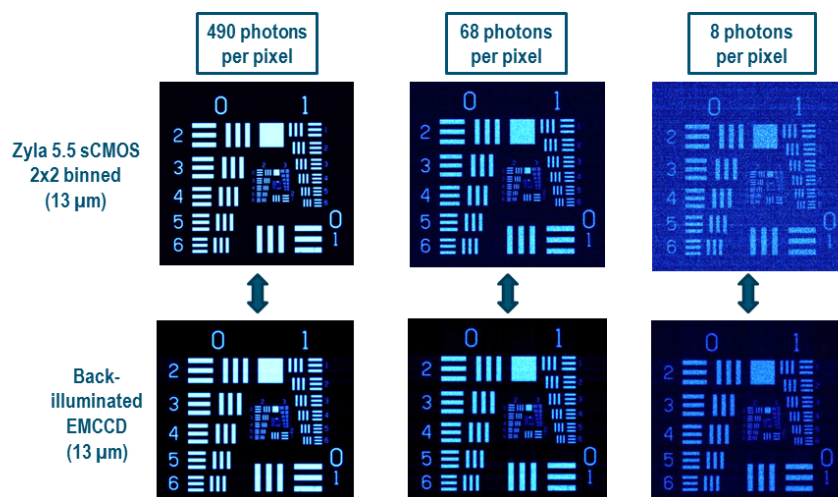
Images at a range of incident light intensity, acquired using back-illuminated EMCCD iXon 888 and Zyla 5.5 sCMOS cameras (2x2 binned pixels). At low light intensities, the Signal to Noise Ratio advantage of the EMCCD is apparent

Input Parameters

- Average QE of each sensor between 500 – 750 nm
- rms read noise values
- Fast sCMOS readout (minimum distortion and maximum frame rate)
- sCMOS 2x2 binned to yield equal pixel size to EMCCD
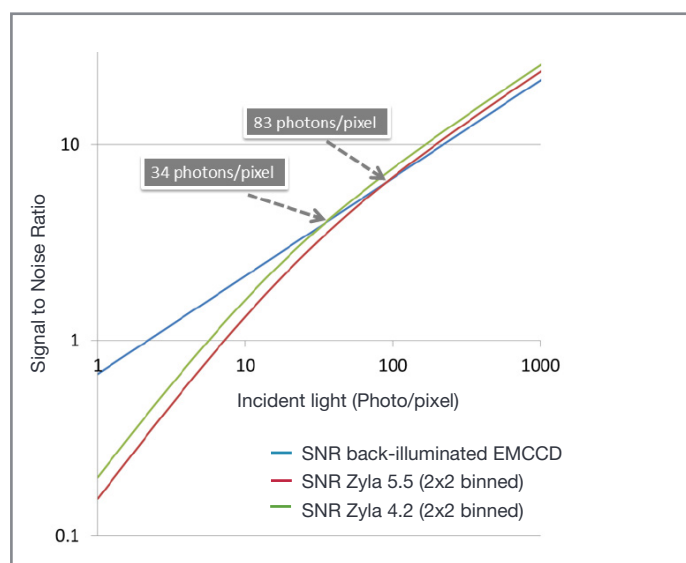
Plot of Signal to Noise Ratio versus Incident Photon Intensity, comparing back-illuminated EMCCD iXon 888 (13 μm pixel size) to 2x2 binned Zyla sCMOS cameras (13 μm pixel size after binning)

SYSTEM SPECIFICATIONS [2]

Model number	888	
Sensor QE options	#BV: Back Illuminated, standard AR coated BVF: Back Illuminated, standard AR coated with fringe suppression UVB: Back Illuminated, standard AR with additional lumogen coating #EX: Back illuminated, dual AR coated EXF: Back illuminated, dual AR coated with fringe suppression	
Fringe Suppression	Available on EX2 and BV sensor options	
Active pixels	1024 x 1024	
Pixel size	13 x 13 µm	
Image area	13.3 x 13.3 mm with 100% fill factor	
Pixel Readout Rate	10 MHz	30 MHz [3]
Minimum temperature, air cooled, ambient 20°C Chiller liquid cooling, coolant @ 10°C, >0.75l/min	-80°C -95°C	-60°C -75°C
Triggering	Internal, External, External Start, External Exposure, Software Trigger	
System window type	#BV and BVF: UV-grade fused silica, Broadband Visible-Near Infrared, 0.5 degree wedge UVB, #EX, EXF: UV-grade fused silica, Broadband Vacuum Ultraviolet-Near Infrared, no wedge	
Blemish specification	Grade 1 sensor (CCD201), as defined by the sensor manufacturer e2v (see www.e2v.com for further details)	
Digitization	16-bit (at all speeds)	
PC Interface	USB 3.0 [12]	
Lens Mount	C-mount	
Direct Data Access	Camera Link 3-tap output	

ADVANCED PERFORMANCE SPECIFICATIONS [2]

Dark current and background events [5,6] Dark current (e⁻/pixel/sec) @ -85°C Spurious background (events/pix) @ 1000x gain / -85°C	0.0005 0.005	
Active area pixel well depth	80,000 e⁻	
Gain register pixel well depth [7]	730,000 e⁻	
Pixel readout rates	Electron Multiplying Amplifier 30, 20, 10 & 1 MHz Conventional Amplifier 1 & 0.1 MHz	
Read noise (e⁻) [8]	Without Electron Multiplication	With Electron Multiplication
30 MHz through EMCCD amplifier	130	< 1
20 MHz through EMCCD amplifier	80	< 1
10 MHz through EMCCD amplifier	40	< 1
1 MHz through EMCCD amplifier	12	< 1
1 MHz through conventional amplifier	6	-
100 kHz through conventional amplifier	3.5	-
Linear absolute Electron Multiplier gain	1 - 1000 times via RealGain™ (calibration stable at all cooling temperatures)	
Linearity [9]	Better than 99%	
Vertical clock speed	0.6 to 4.33 µs (user selectable)	
Timestamp accuracy	10 ns	

FRAME RATES - STANDARD MODE [10]

Binning	Array size						
	1024 x 1024	512 x 512	256 x 256	128 x 128	1024 x 100	1024 x 32	1024 x 1
1 x 1	26	50	95	171	220	498	1163
2 x 2	50	94	170	285	368	699	-
4 x 4	92	167	281	426	552	870	-

FRAME RATES - CROP MODE (OPTICALLY CENTRED FRAME RATES IN BRACKETS) [10]

Binning	Array size						
	512 x 512	256 x 256	128 x 128	64 x 64	1024 x 100	1024 x 32	1024 x 1
1 x 1	93 (78)	190 (251)	670 (697)	2053 (1319)	259	778	9690
2 x 2	170 (143)	350 (426)	1150 (1019)	3123 (1646)	492	1416	-
4 x 4	291 (245)	601 (653)	1772 (1504)	4109 (1857)	887	2370	-

QUANTUM EFFICIENCY (QE) CURVE [11]
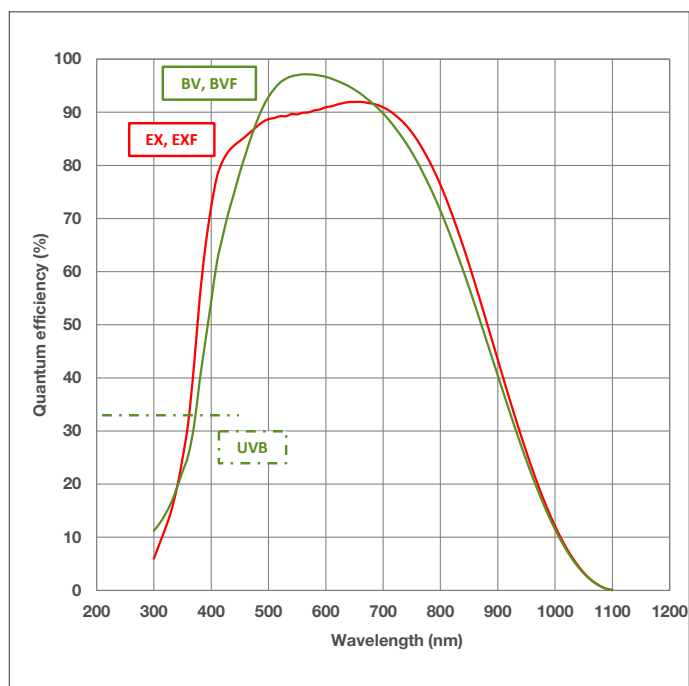
QE VS. FLUOROPHORE EMISSIONS
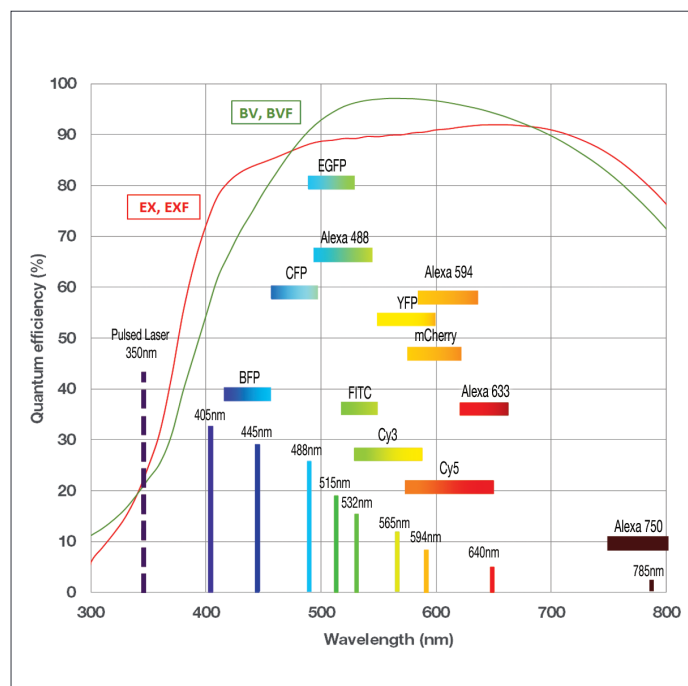
CREATING THE OPTIMUM PRODUCT FOR YOU

How to customize the iXon Ultra 888:

DU-888U3-CS0- **#BV**

example shown

Step 1.

The iXon Ultra 888 comes with 5 options for sensor types. Please select the sensor which best suits your needs.

Step 2.

Please indicate alternative window option if required.

Step 3.

Please indicate which software you require.

Step 4.

For compatibility, please indicate which accessories are required.

Step 1.

Choose sensor finish option

#BV: Back-illuminated, standard AR coated
BVF: Back-illuminated, standard AR coated with fringe suppression
UVB: Back Illuminated, standard AR with additional lumogen coating

#EX: Back-illuminated, EX2 dual AR coated
EXF: Back-illuminated, EX2 dual AR coated with fringe suppression

Step 2.

Select alternative camera window (optional)

The standard window has been selected to satisfy most applications. However, other options are available. The alternative camera window code must be specified at time of ordering.

To view and select other window options please refer to the '**Camera Windows Supplementary Specification Sheet**' which gives the transmission characteristics, product codes and procedure for entering the order. Further detailed information on the windows can be found in the Technical note – '**Camera Windows: Optimizing for Different Spectral Regions**'.

Step 3.

The iXon Ultra 888 requires one of the following software options:

Solis Imaging A 32-bit and fully 64-bit enabled application for Windows (Vista, 7 and 8) offering rich functionality for data acquisition and processing. AndorBasic provides macro language control of data acquisition, processing, display and export.

Andor SDK A software development kit that allows you to control the Andor range of cameras from your own application. Available as 32 and 64-bit libraries for Windows (Vista, 7 and 8), compatible with C/C++, C#, Delphi, VB6, VB.NET, LabVIEW and Matlab. Linux SDK compatible with C/C++.

Andor iQ A comprehensive multi-dimensional imaging software package. Offers tight synchronization of EMCCD with a comprehensive range of microscopy hardware, along with comprehensive rendering and analysis functionality. Modular architecture for best price/ performance package on the market.

Third party software compatibility
Drivers are available so that the iXon range can be operated through a large variety of third party imaging packages. See Andor web site for detail: andor.com/software

Step 4.

The following accessories are available:

OPTOMASK Optomask microscopy accessory, used to mask unwanted sensor area during Crop Mode acquisition.

XW-RECR Re-circulator for enhanced cooling performance
ACC-XW-CHIL-160 Oasis 160 Ultra compact chiller unit
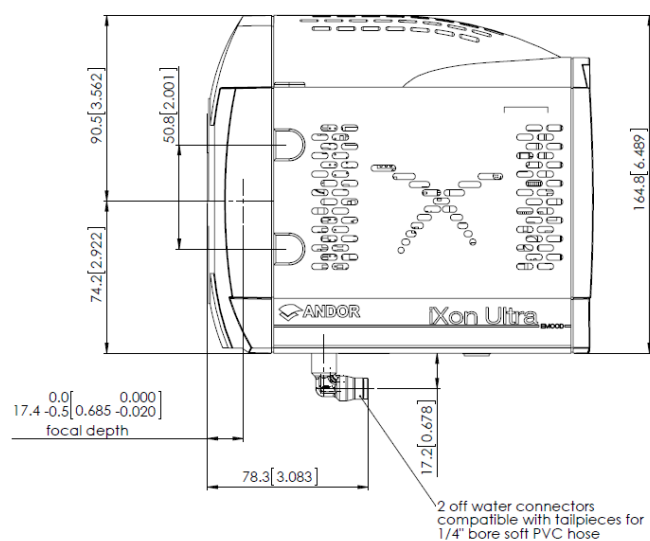**OA-CNAF** C-mount to Nikon F-mount adapter
OA-COFM C-mount to Olympus adapter
OA-CTOT C-mount to T-mount adapter

PRODUCT DRAWINGS

Dimensions in mm [inches]

Third-angle projection

iXon Ultra 888 Power Requirements

- Power Input: +12 VDC ± 5% @ 8 A
- Power Consumption: 96 W max
- Ripple and noise: 120 mV max (peak-peak 0 - 20 MHz)
- External Power Supply: 100 - 240 VAC 50/60 Hz

Connecting to the iXon Ultra

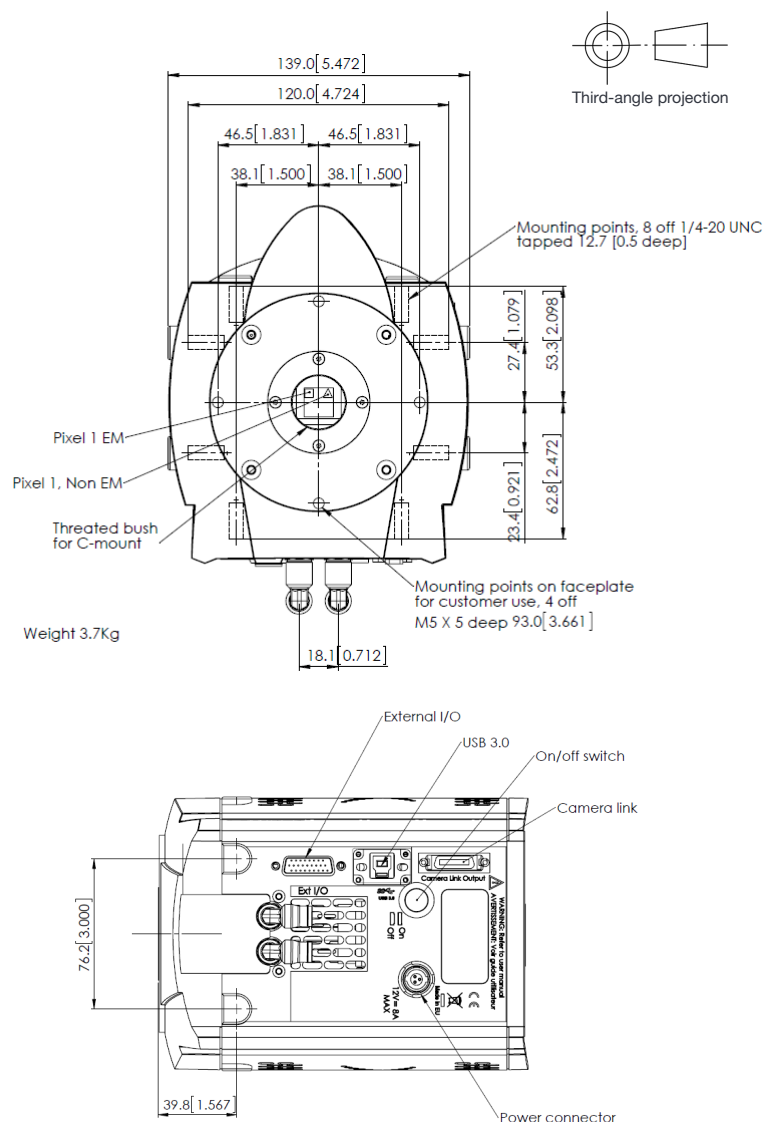**Camera Control**

Connector type: USB 3.0[*12]

Logic
Connector type: 26 way D Type with 8 programmable digital inputs or outputs for control and sensing of up to 8 external device

Camera Link Out
Base 3-tap output (MDR 26 connector). Used as a parallel output for embedded applications.

Minimum cable clearance required
90 mm

TYPICAL APPLICATIONS

Single molecule detection	Cell Motility
Super resolution (PALM, STORM)	Luminescence
TIRF microscopy	FRET / FRAP
Spinning disk confocal microscopy	Fluorescence Correlation Microscopy (multi-beam)
Vesicle trafficking	Microspectroscopy / Hyperspectral imaging
Quantum Science and BEC	Lucky astronomy
Ion signalling (Calcium flux)	Adaptive Optics
Voltage sensitive dyes	Single Photon Counting

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:

Europe
Belfast, Northern Ireland
Phone +44 (28) 9023 7126
Fax +44 (28) 9031 0792

Japan
Tokyo
Phone +81 (3) 3518 6488
Fax +81 (3) 3518 6489

North America
Connecticut, USA
Phone +1 (860) 290 9211
Fax +1 (860) 290 9566

China
Beijing
Phone +86 (10) 5129 4977
Fax +86 (10) 6445 5401

Items shipped with your camera:

1x Andor ACZ-03463: 2m Multi I/O timing cable, offering Fire, External Trigger, Shutter and Arm
1x 3m USB 3.0 cable Type A to Type B
PCIe USB 3.0 Card Adapter (2-Port)[12]
1x Power supply with mains cable
1x Quick launch guide
1x CD containing Andor user manuals

Footnotes: Specifications are subject to change without notice

1. Assembled in a state-of-the-art cleanroom facility, Andor's UltraVac™ vacuum process combines a permanent hermetic vacuum seal (no o-rings), with a stringent protocol to minimize outgassing, including use of proprietary materials.
2. Figures are typical unless otherwise stated.
3. At 30 MHz overclocked pixel readout rate, thermal dissipation from the sensor is higher since a greater proportion of time is spent vertical shifting, and it is necessary to set a higher sensor cooling temperature at this rate. Furthermore, stable cooling performance will depend on other variables such as vertical clock speed, Region of Interest size (Standard or Crop Mode) and ambient temp. As such, the user testing is advised to determine the stable sensor cooling temperature for selected conditions. Status of temperature stability is apparent through the acquisition software.
4. Full Frame readout, fastest unbracketed vertical shift speed with no vertical clock amplitude boost
5. The dark current measurement is averaged over the sensor area excluding any regions of blemishes.
6. Using Electron Multiplication the iXon is capable of detecting single photons, therefore the true camera detection limit is set by the number of 'dark' background events. These events consist of both residual thermally generated electrons and Clock Induced Charge (CIC) electrons (also referred to as Spurious Noise), each appearing as random single spikes above the read noise floor.
   A thresholding scheme is employed to count these single electron events and is quoted as a probability of an event per pixel. Acquisition conditions are full resolution and max frame rate (30 MHz readout; frame-transfer mode; 1.1 µs vertical clock speed; x 1000 EM gain; 10 ms exposure; -95°C).
7. The EM register on CCD201 sensors has a linear response up to ~400,000 electrons and a full well depth of ~730,000 electrons.
8. Readout noise is for the entire system. It is a combination of sensor readout noise and A/D noise. Measurement is for Single Pixel readout with the sensor at a temperature of -75°C and minimum exposure time under dark conditions. Under Electron Multiplying conditions, the effective system readout noise is reduced to sub 1 e⁻ levels.
9. Linearity is measured from a plot of counts vs. exposure time under constant photon flux up to the saturation point of the system.
10. All measurements are made at 30 MHz pixel readout speed with 0.6 µs vertical clock speed. It also assumes internal trigger mode of operation. Frame rates shown are for 'Corner Tethered' ROIs, with 'Optically Centred' ROI frame rates shown within brackets.
11. Quantum efficiency of the sensor at 25°C, as supplied by the sensor manufacturer.
12. iXon Ultra 888 should work with any modern USB 3.0 enabled PC/laptop, as every USB 3.0 port should have its own host controller. iXon Ultra 888 also ships with a USB 3.0 PCI card as a means to add a USB 3.0 port to an older PC, or as a diagnostic aid to interoperability issues.

Recommended Computer Requirements:

- 3.0 GHz single core or 2.6 GHz multi core processor
- 2 GB RAM
- 100 MB free disc space to install software (at least 1 GB recommended for data spooling)
- USB 3.0 Super Speed Host Controller capable of a sustained rate of 60MB/s
- Soild-state drive (SSD) capable of a minimum sustained write speed of 100MB/S for spooling data
- Windows (Vista, 7 and 8) or Linux

Operating & Storage Conditions

- Operating Temperature: 0°C to 30°C ambient
- Relative Humidity: < 70% (non-condensing)
- Storage Temperature: -25°C to 50°C

Power Requirements

- Please refer to page 9

LiXonU888SS 1114 R1