ANDOR™ TECHNOLOGY

Low Light Imaging Cameras

iXon^{EM}+ 888 (back-illuminated)

Features & Benefits

EMCCD Technology
Ultimate in Sensitivity from EMCCD gain - even single photon signals are amplified above the noise floor. Full QE of CCD chip is harnessed (no intensifier).

TE cooling to -95°C
Critical for elimination of darkcurrent detection limit.

RealGain™
Absolute EMCCD gain selectable directly from a linear and quantitative scale.

EMCAL™
Innovative user-initiated self-recalibration of EM Gain.

iCam
Unique innovation that empowers the EMCCD to operate with market-leading acquisition efficiency through live cell microscopy software.

>90% QE back-illuminated sensor Maximum possible photon collection efficiency.

UltraVac™[1]
Critical for sustained vacuum integrity and to maintain unequalled cooling and QE performance, year after year.

Variable readout rates up to 10 MHz
Quantitative accuracy at all speeds and slower readout rate for enhanced 16-bit dynamic range.

Selectable amplifier outputs: EMCCD and conventional
Highly flexible camera optimized for both fast, ultra low-light imaging and 'bright-field' or conventional fluorescence imaging.

High dynamic range and 16-bit digitization available
Extended sensor dynamic range (readout speed dependent) and matched digitization for quantization of dim and bright signals.#

Minimal Clock-Induced Charge
Unique pixel clocking parameters, yielding minimized spurious noise floor.

Cropped sensor mode
Specialised acquisition mode for continuous imaging with fast temporal resolution

Enhanced Baseline Clamp
Essential for quantitative accuracy of dynamic measurements.

"Large Field of View - Megapixel Back-Illuminated EMCCD"

Andor's iXon^{EM}+ 888 back-illuminated EMCCD is the world's first megapixel back-illuminated EMCCD, combining large field of view, single photon detection capability and high Quantum Efficiency (> 90%). iXon^{EM}+ is designed to extract the absolute best from quantitative EMCCD technology across all critical performance parameters.

This new 1024x1024 frame transfer format offers unequalled thermoelectric cooling down to -95°C, industry-lowest clock induced charge noise, and operates at 9 frames/sec (full resolution). EMCCD and conventional CCD readout modes provide heightened application flexibility.

The absolute EM gain multiplication can be varied linearly from unity up to a thousand times directly via RealGain™, a true quantitative EM gain scale. To combat the gain-ageing phenomenon inherent to back-illuminated EMCCDs, Andor's EMCAL™ is a unique and innovative user-initiated routine, performing auto-recalibration of the EM Gain scale, without need for a light source, and circumventing the need for factory recalibration.

Key specifications

Active Pixels	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⁻, typical)	80,000
Gain Register pixel well depth (e⁻, typical)	730,000[♦2]
Max Readout Rate (MHz)	10
Frame Rates (frames per sec)	8.9 (full frame)
Read Noise (e⁻)	< 1 to 47 @ 10 MHz

Quantum Efficiency[♦3]
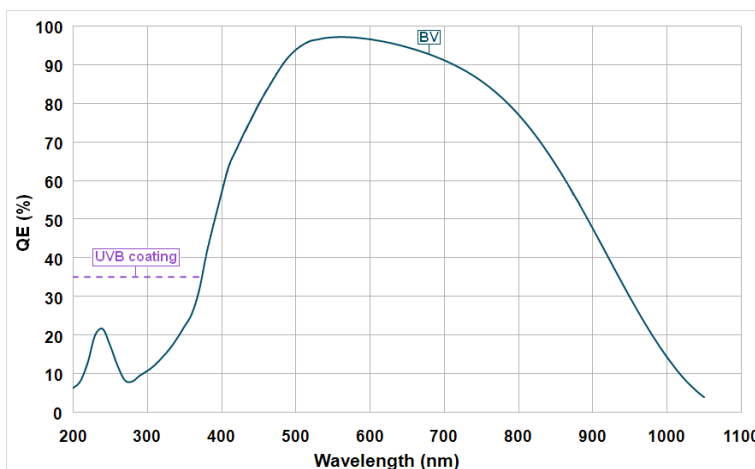
Peak Quantum Efficiency (%)	
CCD Type	**Typical**
BV @ 575 nm	92.5

Technical Specifications

System characteristics

Pixel Readout Rate (MHz)

Electron Multiplying Amplifier	10, 5, 3, 1
Conventional Amplifier	3 & 1
Digitization	True 14-bit @ 10, 5, 3 & 1 MHz readout rate (16-bit available @ 1 MHz)
Vertical Clock Speed (μs)	0.9 to 6.5 (variable)
Linear Absolute Electron Multiplier Gain	1 - 1000 times (software controlled)
Linearity (%, maximum)[4]	1
Triggering	Internal, External, External Start
Camera window type	Single window with double-sided AR coating (standard for BV model)

System readout noise (e⁻)[5]

	Typical	With Electron Multiplication
10 MHz through EMCCD amplifier	47	<1
5 MHz through EMCCD amplifier	35	<1
3 MHz through EMCCD amplifier	27	<1
1MHz (16-bit) through EMCCD amplifier	18	<1
1MHz (16-bit) through Conventional amplifier	6	N/A

Variation of Readout Noise with EM Gain @ 10 MHz Readout Rate
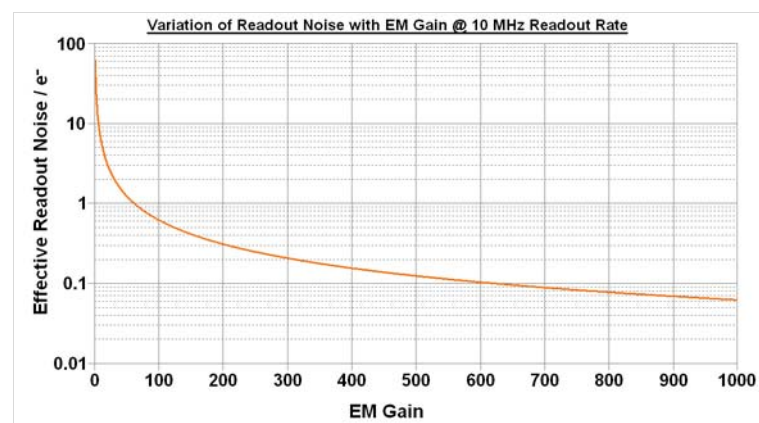
Minimum sensor temperatures (typical)

Air cooled (ambient air at 20ºC)	-80ºC
Water cooled using Re-circulator (ambient air @ 20ºC)	-90ºC
Water cooled using Chiller (@ 10ºC, 0.75 l / min)	-95ºC

Dark current & background events

Dark Current @ -75°C (e⁻/pix/sec)[6]	0.001
EMCCD-Amplified Background Events @ x1000 EM gain,30ms exposure, -85°C (events/pix)[7]	0.01

Blemish specification

As defined by the sensor manufacturer e2V.
Can be accessed in the CCD201-20 Back-illuminated sensor datasheet, downloadable from this web page: **http://www.e2v.com/module/page-357/l3-vision-datasheets-and-technical-notes.cfm**

Max frames per second[8]

	Array size				
Binning	**1024 x 1024 (Full Frame)**	**512 x 512**	**256 x 256**	**128 x 128**	**1024 H x 256 V**
1 x 1	8.9	17.6	34.4	65.6	34.4
1 x 2	17.5	34.1	65.1	119.3	65.1
2 x 2	17.5	34.1	65.1	119.3	65.1
1 x 4	33.6	64.2	117.7	202.4	117.7
4 x 4	33.6	64.2	117.7	202.4	17.7
8 x 8	62.3	114.7	197.6	310.6	197.6

Computer requirements

To handle data transfer rates of 10 MHz readout over extended kinetic series, a powerful computer is recommended, e.g.:

- 3 GHz Pentium (or better)
- 1GB RAM
- 10,000 rpm SATA hard drive preferred for extended kinetic series
- PCI-compatible computer. PCI slot must have bus master capability.
- Available auxiliary internal power connector
- 32 MB free hard disc space

Operating & storage conditions

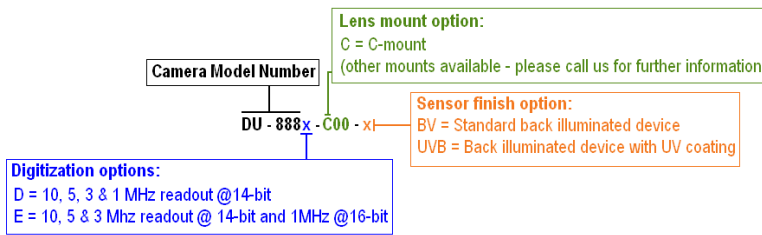|	
Operating Temperature	0ºC to 30ºC ambient
Relative Humidity	< 70% (non-condensing)
Storage Temperature	-25ºC to 55ºC

Power requirements[10]

- +12V - 0.6A
- -12V - 0.3A
- +5V - 3.0A

Specifications are subject to change without notice

Ordering Information

To order the camera you require, please use the following ordering system:

Lens mount option:
C = C-mount
(other mounts available - please call us for further information

Camera Model Number

DU - 888x - C00 - xI

Sensor finish option:
BV = Standard back illuminated device
UVB = Back illuminated device with UV coating

Digitization options:
D = 10, 5, 3 & 1 MHz readout @14-bit
E = 10, 5 & 3 Mhz readout @ 14-bit and 1MHz @16-bit

E.g. a **DU-888D-C00-UVB** is a **UV-enhanced back-illuminated iXon^EM+ 888** camera with **14-bit digitization** at 10, 5, 3 and 1 MHz readout speeds, **EMCCD & Conventional** output amplifiers.

**The iXon^EM+ 888 also requires the following controller card:**

CCI-23 - PCI Controller card

The iXon^EM+ 888 also requires one of the following software options:

Andor Solis	A 32-bit Windows compatible software application with rich functionality for data acquisition and processing. Will run under 32-bit and 64-bit Windows (XP, Vista and 7).
Andor SDK	A software development kit that allows you to control the Andor range of cameras from your own application. Available for 32-bit and 64-bit Windows (XP, Vista and 7) and Linux.
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^EM + range can be operated through a large variety of third party imaging packages.

The following accessories are available for use with the iXon^EM+ 888:

XW-RECR	Re-circulator for enhanced cooling performance
XW-CHIL-150	Chiller/re-circulator for maximum cooling performance
REMOTE CTRL KIT	Programmable remote control for controlling functions from anywhere around the optical set-up
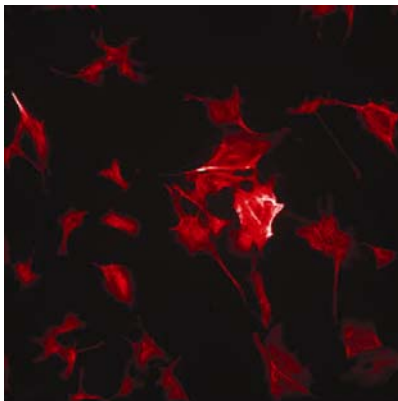
Fluorescently labelled cells, imaged with an iXon^EM+ 888

To compare this field of view compared to other iXon^EM+ models, please go to the following web page:

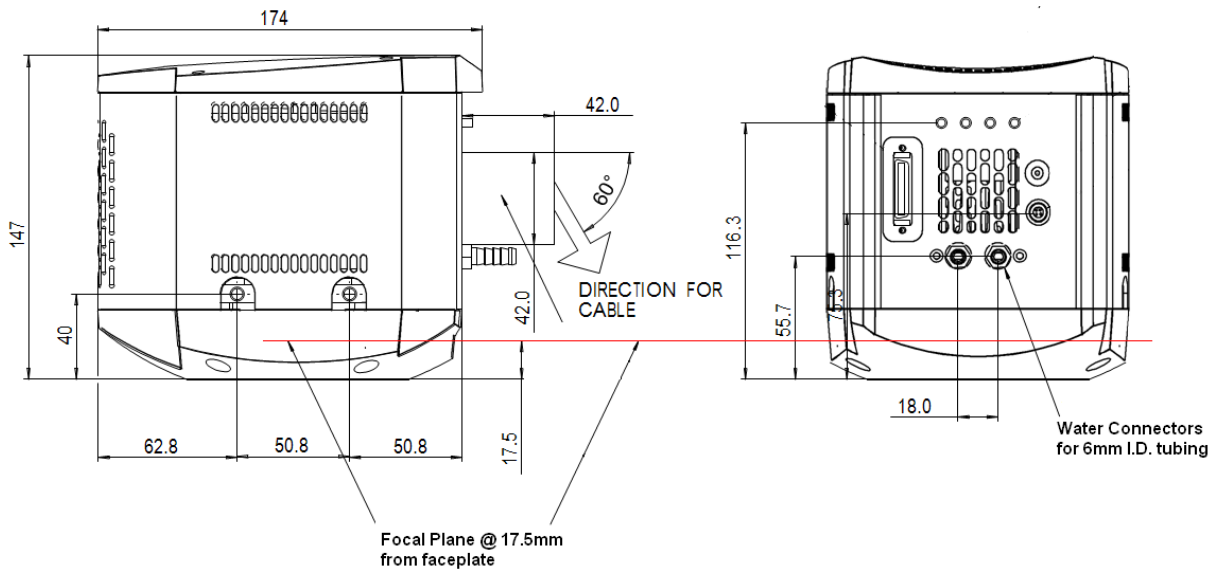**www.andor.com/scientific_cameras/ixon/compare_fields_of_view/Default**

Notes

♦1 Assembled in a state-of-the-art Class 10,000 cleanroom facility, Andor's UltraVac™ vacuum process combines a permanent hermatic vacuum seal (no o-rings), with a stringent protocol to minimize outgassing, including use of proprietary materials. Outgassing is the release of trapped gases that would otherwise prove highly problematic for high-vacuum systems.

♦2 The EM register on CCD201 sensors has a linear response up to 400,000 electrons max. and a full well depth of ~ 730,000 electrons maximum.

♦3 Quantum efficiency of the CCD sensor as measured by the CCD Manufacturer. Can be accessed in the CCD201-20 Back-illuminated sensor datasheet, downloadable from the following web page:
http://www.e2v.com/module/page-357/l3-vision-datasheets-and-technical-notes.cfm.

♦4 Linearity is measured from a plot of Counts vs. Signal up to the saturation point of the system. Linearity is expressed as a percentage deviation from a straight line fit.

♦5 System Readout noise is for the entire system. It is a combination of CCD readout noise and A/D noise. Measurement is for Single Pixel readout with the CCD at a temperature of -85°C and minimum exposure time under dark conditions. Under Electron Multiplying conditions, the effective system readout noise is reduced to sub 1e^- levels. Noise values will change with **p**re-**a**mplifier **g**ain (**PAG**) selection. Values quoted are measured with highest available PAG setting.

♦6 This value is obtained using the traditional method of measuring dark current, as for any CCD camera, i.e. taking a long integration time (with no EM gain applied) to get a darksignal that is well above the read noise. The dark current measurement is averaged over the CCD area excluding any regions of blemishes.

♦7 Using Electron Multiplication (EM) the iXon^EM+ is capable of detecting single photons, therefore the true camera detection limit is set by the number of 'dark' background events. These background events consist of both residual thermally generated electrons and **C**lock **I**nduced **C**harge (**CIC**) electrons (also referred to as **Spurious Charge**), each appearing as random single spikes that are well 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 (10 MHz readout; frame-transfer mode; 1.7μs vertical clock speed; x 1000 EM gain; 30 ms exposure; -85°C). It is important to realise that to get to this single photon detection regime there must be sufficient cooling, such that there is significantly less than 1 event per pixel.

♦8 The max frames / second for iXon^EM+ imaging CCDs is the maximum speed at which the device can acquire images in a standard system. Shown are the frame rates at 10 MHz digitization rates for a range of binning or array size combinations. All measurements are made with 0.9μs vertical clock speed. It also assumes internal trigger mode of operation

♦9 These power requirements are the maximum load that will be drawn from the computer for the camera head and controller card combined.

Dimensions (in mm)

Weight: 3.4kg [7.5lb]
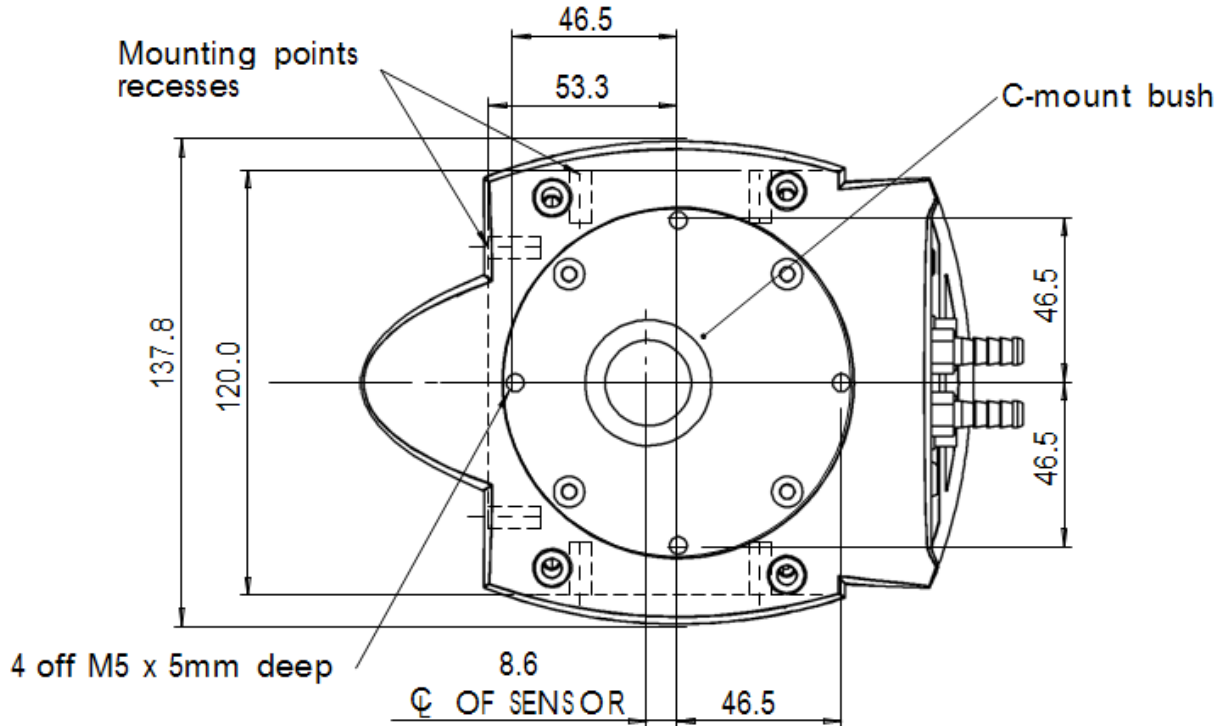
NOTE: There are mounting holes (¼-20UNC) located on three sides of the camera. They are positioned centrally at a distance of 40mm from the front of the front face.