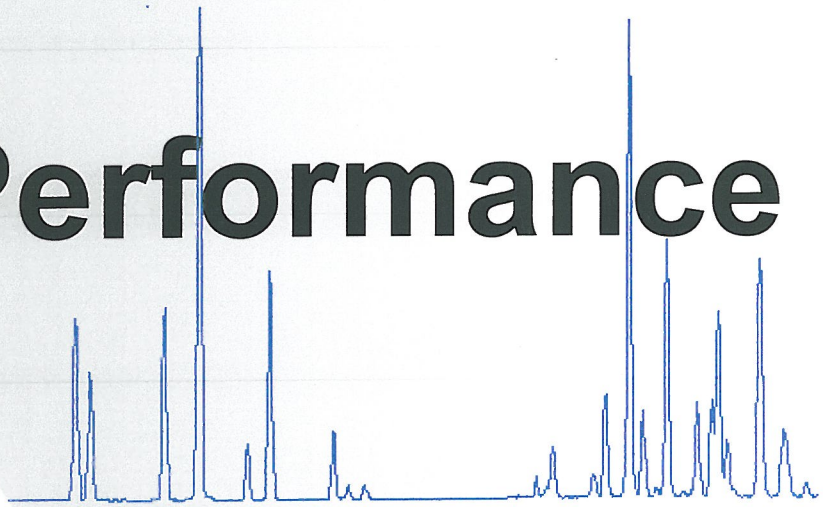
ANDOR
TECHNOLOGY

SYSTEM Performance



Performance Booklet

Issue 1 Rev 0
11/02

International Headquarters
Andor Technology Limited
Springvale Business Park
Belfast

Congratulations.

You have selected one of the finest multichannel detectors available anywhere in the world today !

This high performance instrument has been individually built for you and tested in accordance with Andor's ISO 9001:2000 quality régime.

The documents in this folder are your individual assurance that your new multichannel detector has been rigorously tested and its performance recorded in detail. You can be confident that your detector meets Andor's exacting standards.

We hope you find use of our detector rewarding and we look forward to working with you again in the future !

Yours sincerely,

Andor Technology

PS Don't forget to fill in and return your Warranty Registration today. It helps us.... to help you!

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CCD PERFORMANCE

System Overview

Description	Model						Serial Number
CCD Head ▽	D	U	9	34N	-	BR-DD	CCD-10102
TE Cooler performance (✔)	Moderate		High		Ultra-high	✔	
Accessories	Power Supply Unit (PS -24)						PS -25
							✔
	SO-		LM-		MFL-		
Serial/Batch Number							
Other							

▽ Sensor types are defined in Table 1 using the last two letters in box Model Number.

CCD Details

Manufacturer / Model No.		Pixels	Serial Number
E2V	CCD47-10	1024x1024, 13μm^2	04473-10-20
E2V	CCD57-10	512x512, (FT), 13μm^2	
E2V	CCD77-00	512x512, 24μm^2	

Special Feature	(✔)		(✔)
NIMO	✔	AR coated Window	
Fringe Suppression	✔	Custom Cables	
Shielded Anti-Blooming		Custom Mounting Flange	
MgF_2 Input			

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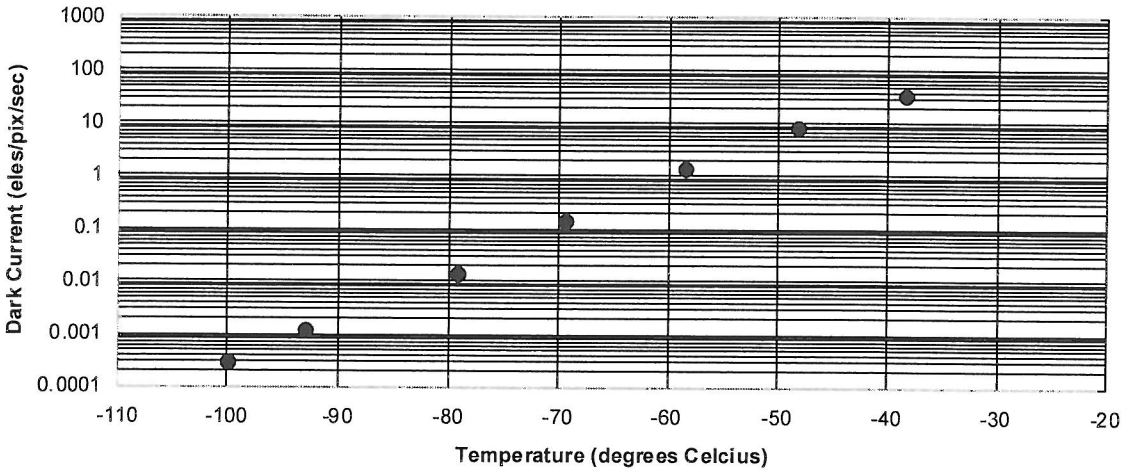
CCD PERFORMANCE

Summary of System Test Data

Readout Noise #1 and Base Mean Level

A/D Rate (MHz All 16 bit)	Preamp setting	CCD Sensitivity #3 eles per A/D count	Single Pixel Noise electrons	Full Vert Bin Noise electrons	Base Level #2 (Counts)
2.5	x1	5.0	15.2	14.7	1154
2.5	x2	2.4	10.4	10.2	2415
2.5	x4	1.0	8.5	8.4	4335
1.0	x1	4.7	13.0	12.8	1110
1.0	x2	2.3	8.4	8.4	2293
1.0	x4	1.2	7.2	7.3	4525
0.05	x1	5.6	5.7	6.1	582
0.05	x2	2.8	4.6	4.3	1646
0.05	x4	1.4	3.6	4.0	3696
Saturation Signal per pixel			70631	Electrons/pixel	

CCD Dark Current



Minimum Dark Current Achievable #4	0.0003	electrons/pixel/sec		
@ Sensor Temperature of #5	-100.02	°C	16.0	°C cooling water
		With PS-25		
CCD Dark Current Uniformity better than #6	0.33	electrons/pixel/sec		

Linearity and Uniformity

Linearity better than #7	1	% over 16 bits
Response Uniformity better than #8	1.95	%

Response Defects

White/Black Spots ♦9

(X, Y)

(387, 606)			
(X, X)			

White/Black Columns ♦10

Column numbers indicated.

X	X
X	X

Traps ♦11

Column numbers indicated.

X	X

Dark Current Defects

Hot Spots ♦12

(X, Y)

(X, X)			

Hot Columns ♦13

Column numbers indicated.

X	X

Test Conditions

Readout Noise tested at	-80	°C with	16	°C water
Base Mean Level measured at	-80	°C with	16	°C water
Dark Current Uniformity tested at	-50	°C with	16	°C water
Blemishes tested at	-50	°C with	16	°C water

Custom Testing

System Passed for Shipping

Signed ROBERT CREIGHTON

Date 26TH JUNE 2009

Hardware Version #	HEADBOARD	FPGA
	AB	7.255
Shipping Software Version #	SOLIS	SDK
	--	--
Testing Software Version #	SOLIS	SDK
	4.12.30003.0	2.84.30003.0

▽ Table 1; Key code to define the meanings of the last two letters in the Model Number

Sensor Options			
OE	Open electrode	BV	BI + VIS (550nm) optimised)
FI	Front illuminated (FI)	BR	BI + NIR (850) optimised
UV	FI+UV coating	BR-DD	BI + NIR +deepdepletion
FO	FI + Fibre optic	BN	BI with no AR coating
FI-DD	FI + deep depletion	FK	Fast Kinetics (masked; 3011 only)
BU2	Back Illuminated (BI) + 250nm UV optimised	KT	Kodak FI coating
BU	BI + UV (350nm) optimised		

Performance Notes

*1 Readout Noise is measured for both single pixel (SP) and fully vertically binned (FVB) with the CCD in darkness at temperature indicated and minimum exposure time. Noise values will change with pre-amplifier gain selection [PAG].

*2 Average electronic DC offset for CCD in darkness at temperature indicated and minimum exposure time under dark conditions measured by single pixel (SP) for imaging systems and by (FVB) for spectroscopic systems.

*3 Sensitivity is calculated in photoelectrons per A/D count from measurements of the Photon Transfer Curve.

*4 Dark current falls exponentially with temperature. However, for a given temperature the actual dark current can vary by more than an order of magnitude from device to device. The devices are specified in terms of minimum dark current achievable rather than minimum temperature.

*5 Minimum temperature achieved for thermoelectric (TE) cooler set to maximum value with water cooling

*6 RMS (root mean square) deviation of dark current for fully binned operation for spectroscopic cameras, or full resolution image for imaging cameras, under dark conditions at temperature indicated (pixel/column defects not included). This variation is mainly cosmetic since it is fully subtractable without significant loss of performance.

*7 Linearity is measured from a plot of Counts vs. Signal over the 16 bit dynamic range. Linearity is expressed as a %age deviation from a straight line fit. This quantity is not measured on individual systems.

*8 RMS (root mean square) deviation from the average response of the CCD in fully binned operation for spectroscopic cameras, or full resolution image for imaging cameras, illuminated with uniform white light (defects not included).

*9 A spot can be up to 3 pixels in size. White/black spots have signals >25% above/below the average (25% contrast) with uniform illumination across the sensor.

*10 Columns whose signals have >10% contrast in binned operation with uniform illumination across the sensor for spectroscopic cameras, ≥ 10 black spots per column for imaging cameras.

*11 Pixels which absorb charge as it is clocked through the defective area. When the light source is switched off, the signal from the trap appears to drop off more slowly than the signal from the surrounding pixels.

*12 A spot can be up to 3 pixels in size. For Grade A devices, hot spots are counted if they exhibit >50 times the maximum specified dark current at the test temperature indicated.

*13 A column is considered defective if >10 pixels are affected, or if the column exhibits >2 times the maximum specified dark current at the test temperature indicated.

iKon-M 934 BR-DD

ANDOR™ TECHNOLOGY

low-light imaging

Features & benefits

Min operating temp of -100°C with TE cooling
Unparalleled TE cooling performance for negligible dark current, without the aggravation or safety concerns associated with LN_2.

Fringe Suppression Technology™
Minimizes fringing (etaloning) effects

Peak QE of >90%, optimized for NIR
Very High detector sensitivity in near infra-red.

Multi-Megahertz pixel readout
High frame rates achievable.

Simple USB connection
Simple USB 2.0 connection direct from back of camera – no controller box required!

Industry fastest vertical shifts
3µs temporal resolution in 'Fast Kinetics Acquisition' mode.

Single AR-coated window design, incorporating UltraVac™ guaranteed hermetic vacuum seal technology
Ultimate reliability and sustained lifetime performance characteristics with maximum photon throughput.

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

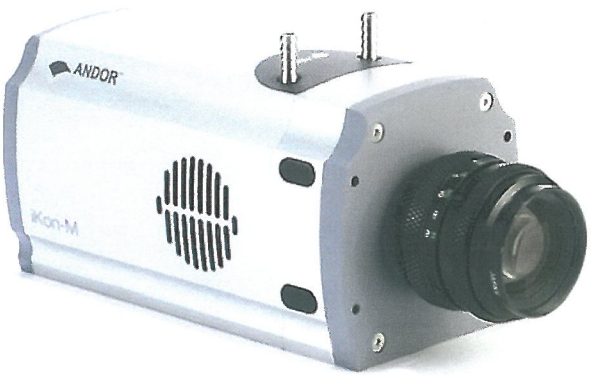
Enhanced Baseline Clamp
Essential for quantitative accuracy of dynamic measurements.

13 x 13µm pixel size
Optimal balance of dynamic range and resolution

Andor Solis software / SDK (Linux SDK available)
Friendly Windows user interface offers intuitive acquisition optimization, system integration, automation and advanced data manipulation facilities.

Integrated shutter
C-mount shutter as standard. Close during readout to avoid vertical smear.

"Deep Depletion model for NIR Imaging"



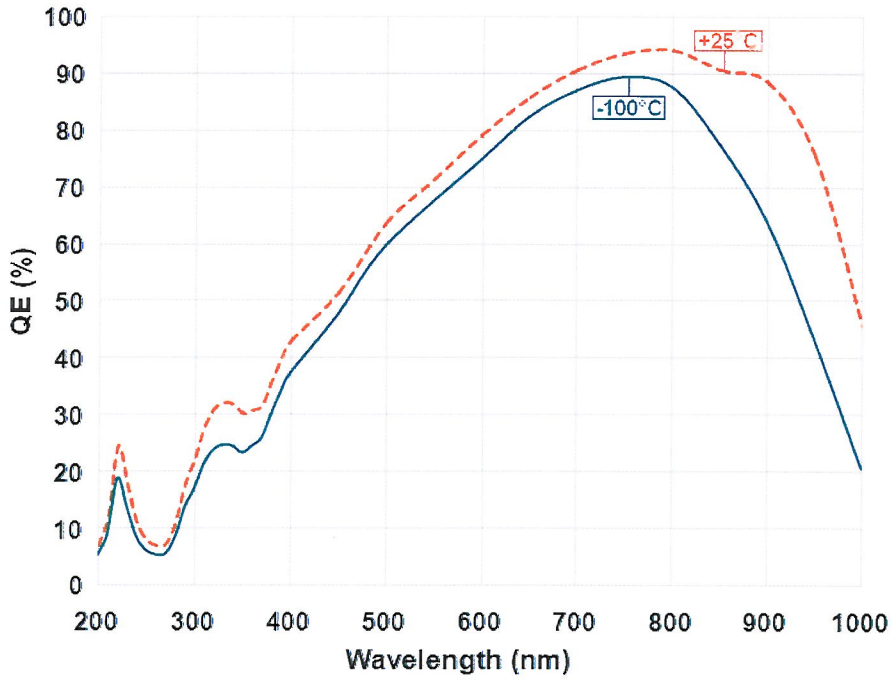
Andor's iKon-M 934N BR-DD is designed to offer ultimate performance for NIR applications, delivering > 90% QE beyond 800nm. Andor's 'BRD' cameras are the only Deep Depletion systems that incorporate Fringe Suppression Technology™ to minimize fringing effects.

The 1024 x 1024 array boasts high resolution 13µm pixels, and benefits from negligible darkcurrent with thermoelectric cooling down to -100°C, critical to optimize the sensitivity of Deep Depletion sensors. The iKon-M platform offers both multi-Megahertz readout and USB 2.0 connectivity. Industry fastest vertical shifts combined with fast kinetics acquisition mode, comprehensive trigger modes and custom coated wedge window render the DU934N BR-DD an ideal solution for NIR optimized Bose Einstein Condensation applications

Camera overview

Active Pixels[1]	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)	100,000
Output Saturation (e^-, typical)[2]	200,000
Frame Rate (frames per sec)[3]	2.25
Read Noise (e^-, typical)	
@ 50 kHz	2.5
@ 2.5 MHz	10.3

Quantum efficiency[4]



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iKon-M 934 BR-DD

low-light imaging

Technical specifications

System characteristics

Dummy Pixels	24, 24, 3, 3
Pixel Readout Rate (MHz)	2.5, 1, 0.05
Linearity (%, maximum)[5]	1
Vertical Clock Speed (µs)	3 to 44 (software selectable)
Software Selectable Sensitivity (e⁻ per A/D count, typical)	4, 2, 1
Digitization	16 bit (at all readout speeds)
Camera window type	Single quartz window, AR coated on both sides, 0.5° wedge. **NOTE: Custom coated windows can be ordered on request, e.g. 780nm optimized for Rb BEC experiments.**

System readout noise[6]

Pixel Readout Rate (MHz)	Readout Noise (e⁻, typical)
0.05	2.5
1	8.0
2.5	10.3

Minimum sensor temperatures (typical)[7]

Air cooled (ambient air at 20°C)	-80°C
Re-circulator (XW-RECR) (ambient air @ 20°C)	-95°C
Water-cooled (@ 10 °C, 0.75 l / min)	-100°C

Dark current (back-illuminated)

@ -80°C (typical)	0.01 e⁻/pixel/sec
@ -100°C (typical)	0.008 e⁻/pixel/sec

Operating & storage conditions

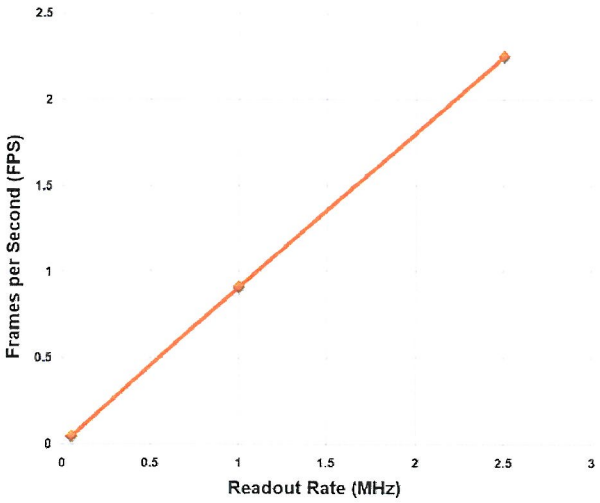
Operating Temperature	0°C to 30°C ambient
Relative Humidity	< 70% (non-condensing)
Storage Temperature	-25°C to 55°C

Power requirements

- 5Vdc with 15 Watts
- 7.5Vdc with 30 Watts (PS-25 only)
- ±15Vdc with 3 Watts

Rear view showing connections

Full frame rate[8]



Max frames per second[9]

1MHz				
Binning	**Full Frame**	**512 x 512**	**256 x 256**	**128 x 128**
1x1	0.91	1.81	3.58	7.0
2x2	2.9	4.39	7.68	13.98
4x4	8.03	9.54	15.3	26.1
8x8	18.57	18.86	28.24	44.84

2.5MHz				
Binning	**Full Frame**	**512 x 512**	**256 x 256**	**128 x 128**
1x1	2.25	4.4641	8.76	16.87
2x2	5.78	9.82	17.73	32.051
4x4	12.96	19.76	33.4	56.28
8x8	25.63	36.46	57.67	89.13

Computer requirements

To handle data transfer rates of 2.5 MHz readout over extended kinetic series, a powerful computer is recommended, e.g.:

- 2.4 GHz Pentium (or better) + 1Gbyte RAM
- 32 MB free hard disc to install software
- USB 2.0
- Windows 2000 or better

Need more information? Please contact us at:

International Office	US Office
Phone: +44 28 9023 7126	**Phone:** 800.296.1579
Fax: +44 28 9031 0792	**Fax:** 860.290.9566
Japanese Office	**Chinese Office**
Phone: +81 3 3511 0659	**Phone:** +86-10-5129-4977
Fax: +81 3 3511 0662	**Fax:** +86-10-6445-5401

Ordering information & notes

To order this camera, please quote following model number:

DU934N-BR-DD

The DU934N BR-DD is supplied with the following power supply:

PS-25	Switchable power supply for maximum air or water cooling, with 2x settings; **standard** or **deep cooling**.

The DU934N BR-DD also require one of the following software options:

Andor Solis (i)	A ready-to-run Windows 2000 or XP-based package with rich functionality for data acquisition and processing.
Andor SDK	A ready-to-run Windows 2000 or XP-based package with rich functionality for data acquisition and processing. Available for Windows 2000 or XP and Linux.

The following accessories are available for use with the DU934N BR-DD:

XW-RECR	Re-circulator for enhanced cooling performance
XW-CHIL-150	Chiller/re-circulator for maximum cooling performance
XU-TRAN	USB 2.0 Ranger - Transmitter
XU-RECR	USB 2.0 Ranger - Receiver
XU-POWR	15W External Power Supply. **NOTE: The XU-TRAN & XU-RECR each need their own supply.**
OA-CCFM	C-mount to Canon F-mount adapter
OA-CNAF	C-mount to Nikon F-mount adapter
OA-COFM	C-mount to Olympus F-mount adapter
OA-CTOT	C-mount to T-mount adapter
OA-ECAF	Auto ext. tubes (set of 3) for Canon AF
OA-ECMT	Auto ext. tubes (set of 3) for C-mount
OA-ENAF	Auto ext. tubes (set of 3) for Nikon AF

Specifications are subject to change without notice

♦1 Edge pixels may exhibit a partial response.

♦2 The output saturation that is actually accessible by the CCD system is dependent upon the sensitivity setting & binning mode selected.

♦3 Based on a horizontal pixel readout rate of 2.5 MHz and a vertical shift speed of 3µs.

♦4 Quantum efficiency of the CCD sensor as measured by the CCD Manufacturer.

♦5 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.

♦6 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 -50°C and minimum exposure time under dark conditions. Noise values will change with pre-amplifier gain (PAG) selection. Values quoted are measured with highest available PAG setting.

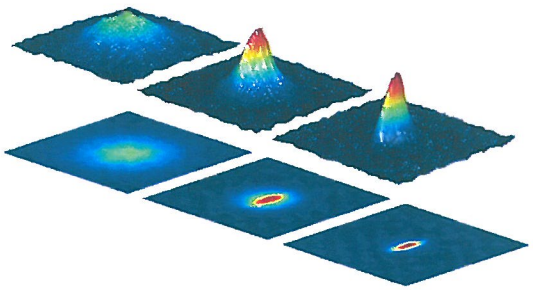
♦7 Cooling is provided by the use of an external, mains driven, power supply. Minimum temperatures listed are typical values. Systems are specified in terms of minimum dark current achievable rather than absolute temperature.

♦8 The graph shows the full frame rates possible when reading out the sensor at 2.5, 1 and 0.05 MHz pixel readout rates, using 3µs vertical clock speed.

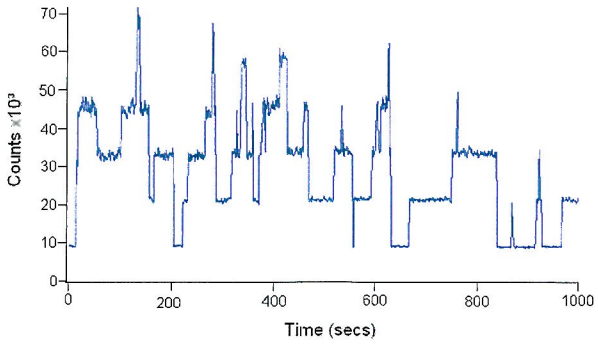
♦9 Shown are the frame rates at 1 MHz and 2.5 MHz digitization rates for a range of binning or array size combinations. All measurements are made with 3µs vertical shift speed. It also assumes internal trigger mode of operation and 'zero' exposure time.

Applications

- Astronomy
- Biochip reading
- Bioluminescence/Chemiluminescence
- **B**ose-**E**instein **C**ondensation (**BEC**)
- Fluorescence microscopy
- High throughput screening
- Hyper-spectral imaging
- Laser Induced Fluorescence (**LIF**)
- Neutron Radiography
- Pressure sensitive paints
- Raman imaging
- Semiconductor analysis



Low-light fluorescence image of one million trapped rubidium atoms cooled to micro Kelvin temperatures.

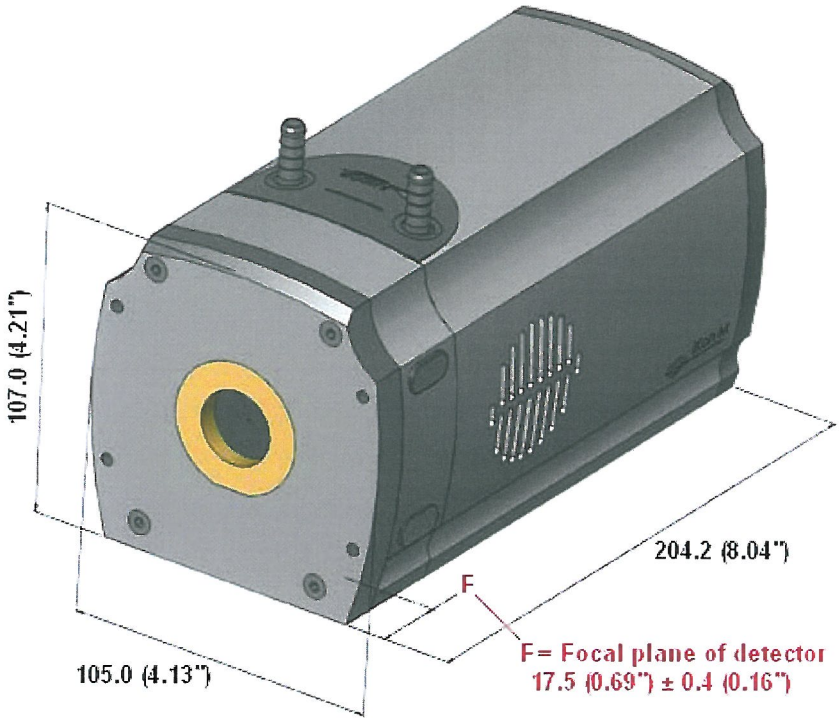


Fluorescence from a few-atom MOT v time, showing the discrete steps characteristic of single atoms entering and leaving the trap.

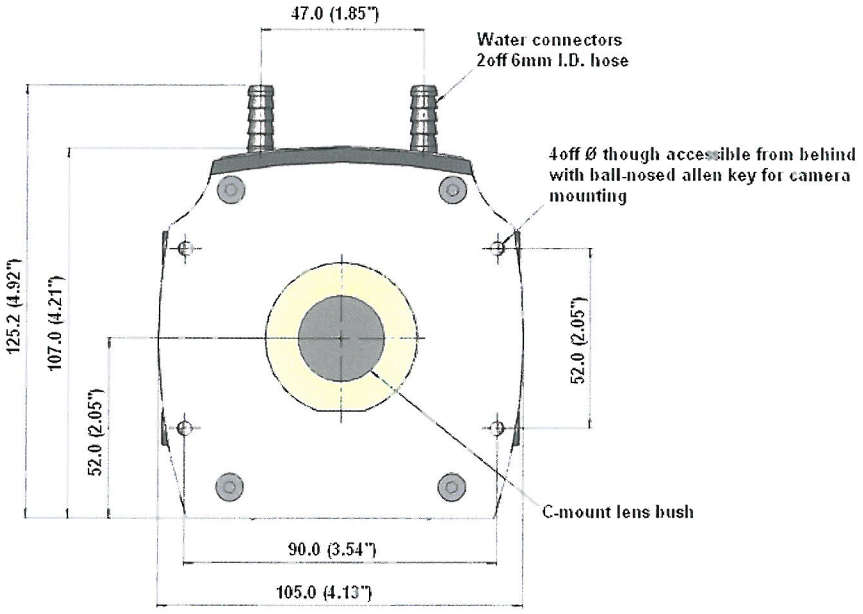
Dimensions

Weight: 2.6 Kg [5.7 lb]

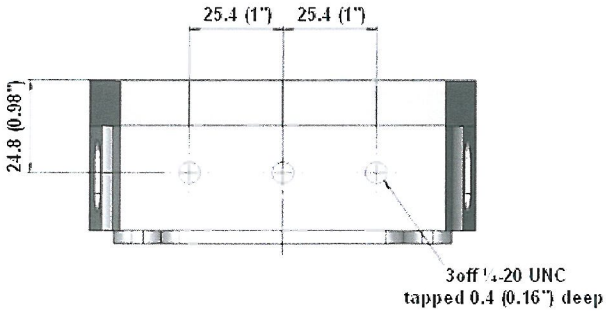
Side / front view



Front face

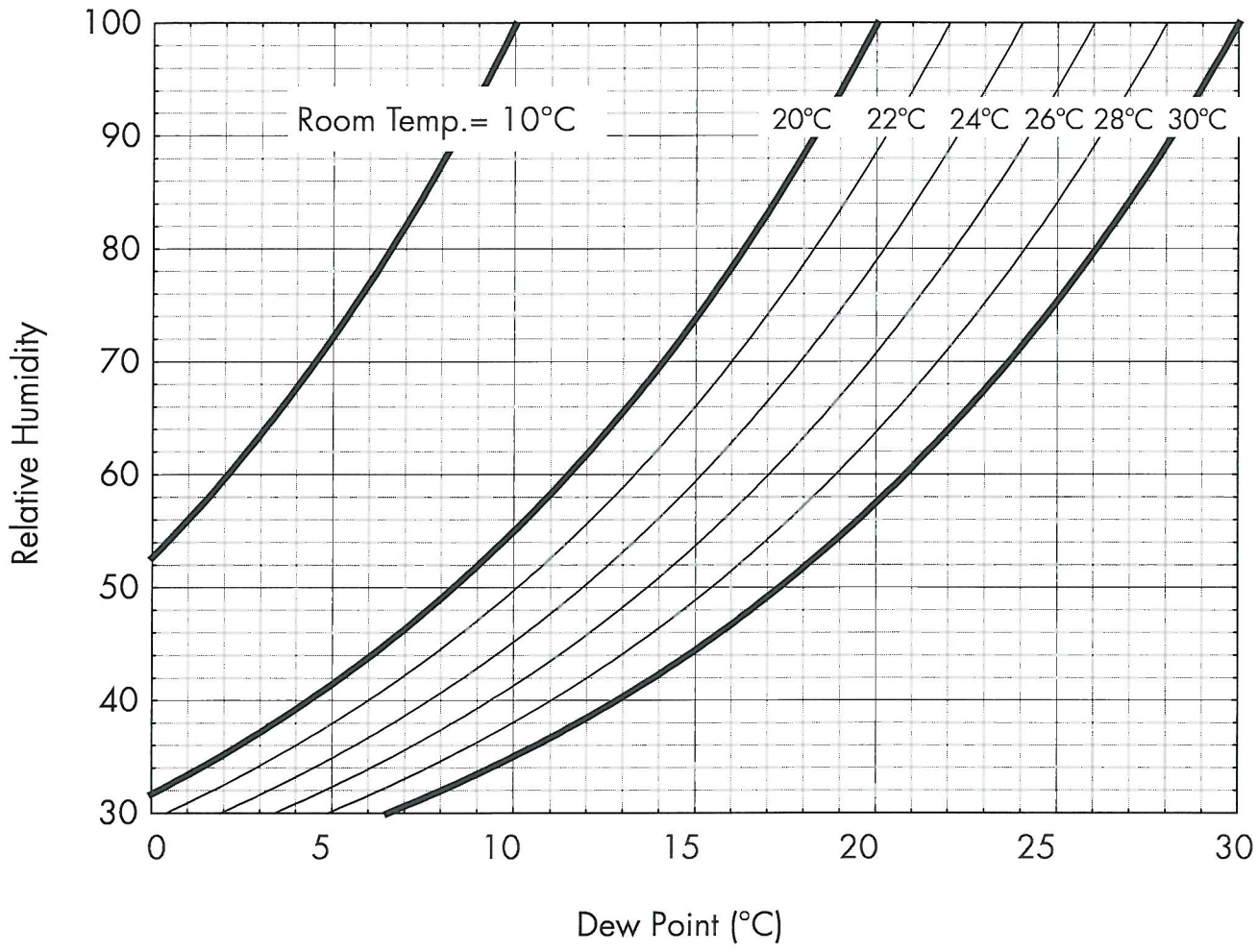


Mounting hole locations



Dew Point

To achieve ultimate cooling performance you need 10°C water. In humid conditions this will cause condensation and hence damage to the CCD head. Unfortunately in such con-ditions you will have to use warmer water. The following graph gives you a guideline to determine the dew point and select water temperature in humid conditions. For example if the room temperature is 24°C and relative humidity is 50%, the dew point can be determined from the graph to be 12°C. Therefore water temperature must be higher than dew point (i.e. >12°C). Typical water temperature should be 2°C higher than dew point (in this example ~14°C). This will limit the minimum CCD temperature (refer to the table in the manual).



Please contact: Dr. Markus Wewer, phone: +49/6151/8806-754, eMail: wewer@lot-oriel.de
or Olaf Koschützke, phone: +49/6151/880643, eMail: koschuetzke@lot-oriel.de