nüvü cameras

every photon counts

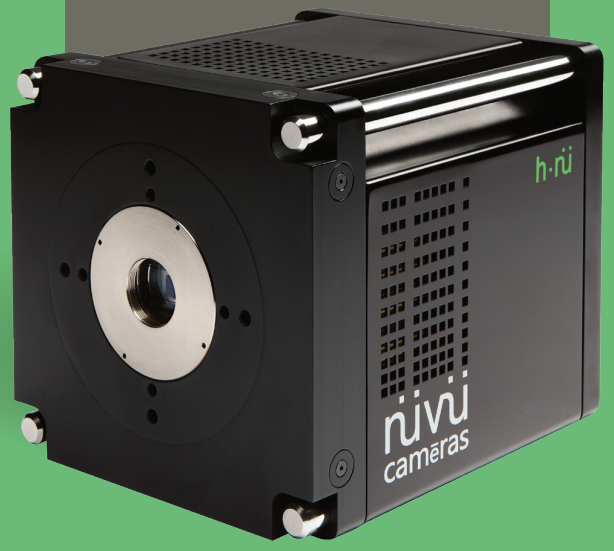
h·nü128^{AO}

BUILT FOR SPEED

MORE THAN 1000 FPS FULL FRAME, IMAGING EVEN IN NEAR-TOTAL DARKNESS

A NEW STANDARD FOR LOW LIGHT IMAGING

NÜVÜ™ REINVENTS THE ELECTRONICS BEHIND THE EMCCD DETECTOR



OUTSTANDING SNR THANKS TO:

- Stabilized on-chip thermoelectric air cooling down to -60 ± 0.01 °C for minimal background signal
- Patented electronics decreasing inherent EMCCD camera noise for true photon counting
- Lowest background signal and highest electron-multiplying gain, up to 5000, in inverted mode of operation (IMO) for optimal results in ultra low-light conditions
- Vibration reduction technology while sufficient liquid cooling is provided

ULTIMATE SENSITIVITY enabling highly efficient low-flux imaging, hence faster acquisitions, with frame rates exceeding 1004 fps in full frame at 20 MHz readout rate

SUPERIOR IMAGE QUALITY thanks to greater charge transfer efficiency

NO NOISE-FILTERING ALGORITHMS: The amount of noise generated is simply lower, eliminating the risk of removing genuine photoelectrons

Lowest background signal for superior SNR

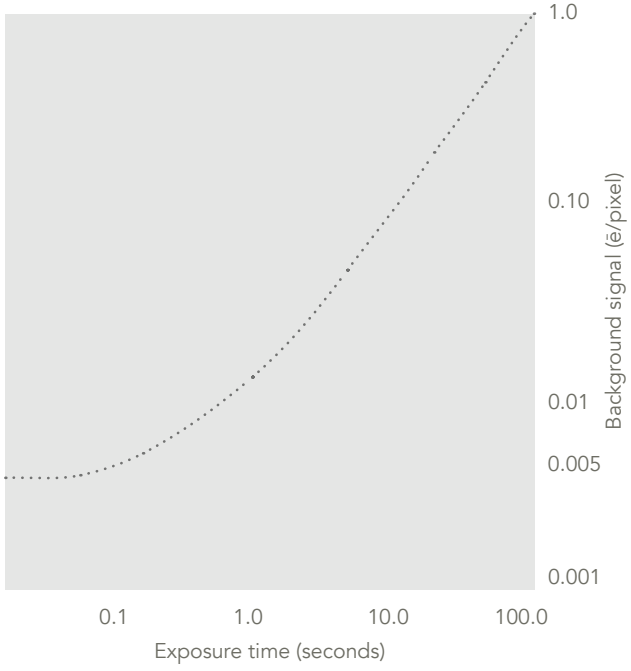


Figure 1

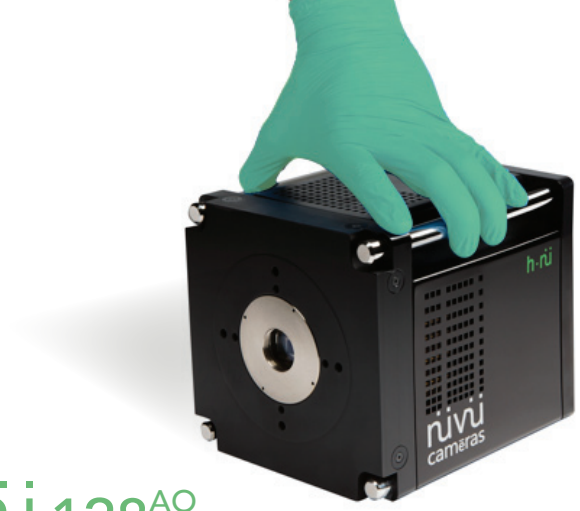
h·nü 128^{AO} dark frames mean signal as a function of exposure
Data measured at 10MHz with an EM gain of 1000 at -60°C.

SIMPLE INTEGRATION INTO A WIDE VARIETY OF SOFTWARE SYSTEMS

Nüvü Camēras offers the highest standard of EMCCD technology in a compact thermoelectrically cooled camera. The technology at the heart of the HNü was originally designed for astronomy, where the need for state-of-the-art instruments drives innovation. Now optimized and extended to a broad range of applications, the user- friendly HNü provides many advantages to efficiently bridge the gaps between purchase, setup, discoveries, and publications.

- › NüPixel control, acquisition and analysis software
- › Software development kit (SDK) for customizable programming
- › Various drivers available for commercial software
- › Worldwide professional customer support

Consultation services are available on demand.



h·nü 128^{AO}

CHARACTERISTICS	SPECIFICATIONS
Digitization	16 bits
Electron-multiplying gain	1 - 5000
Selectable stabilized cooling temperature at maximum full frame readout of 20 MHz	-70^{0}C via liquid cooling[1] -60^{0}C via air cooling
On-chip temperature stabilization	± 0.01^{0}C
Quantum efficiency	> 90% at 600 nm (see Figure 3)
EM register pixel well depth[2]	800 kē
Spectral range	250 - 1100 nm
Triggering	Internal or external Selectable signal polarity
Exposing time resolution	4 ns
Exposing time range[3]	25 ns - days
Timestamp resolution	4 ns

Table 1 HNü128^{AO} Characteristics and Specifications

FEATURES	BENEFITS
EM gain range of 1 – 5000	Lowest effective readout noise Unmatched single photon detection capabilities
Lowest clock-induced charges levels (CIC)	Highest SNR as a result of lowering the CIC, the dominant noise source of EMCCDs
Patented technology optimized for true photon counting	Linear and photon counting modes are available in EM operation
Highest horizontal charge transfer efficiency	Clearer images No pixel leaking
Robust cooling performance	Negligible dark noise at full frame rate Superior charge transfer efficiency
Highest quantum efficiency	Best sensitivity available thanks to back-illuminated grade 1 EMCCD detector (see Figure 3)
Pixel readout rate up to 20 MHz	Fastest acquisition speed for a 128 x 128 EMCCD camera
Time stamping	High-precision time-labelling of every acquisition GPS input for absolute time tagging (optional)
mROI	Select multiple customizable regions of interest on the detector to increase acquisition rates
Cropped-sensor mode	Faster acquisition rates for a region of interest by masking part of the EMCCD detector[4] Greater acquisition versatility using customizable size and position for the cropped region of interest

Table 2 HNü AO Features and Benefits

FASTER FRAME RATES FOR SENSITIVE IMAGING

Available readout rates through the EM channel are 1 MHz, 5 MHz, 10 MHz, and 20 MHz.

BINNING[5]	REGION OF INTEREST		
	128 × 128	64 × 64	32 × 32
1 × 1	1004	1838	3144
1 × 2	1814	3107	4826
1 × 4	3035	4725	6548
1 × 8	4536	6316	7857
1 × 16	5892	7391	8463
1 × 32	6608	7634	8277
Cropped-sensor mode		3161	6699

Table 3 HNü128 Frame Rates for Different Binning Values and Regions of Interest

Frame rates are measured at 20 MHz in EM mode. Other readout speeds and frame rates are also available, as are different EMCCD detector sizes.

WHEN EVERY PHOTON COUNTS

The EMCCD technology is perfectly suited for low-light applications requiring minimal background noise due to its negligible effective read-out noise enabled through high EM gain. In linear mode of operation, the EM gain cannot be precisely determined on a per- pixel basis because of its stochastic nature. It however generates an excess noise factor (ENF) that, for high EM gains, leads to a degraded SNR. In fact, it affects the SNR the same way halving the quantum efficiency would. With photon counting (PC) mode of operation, Nüvü Camēras efficiently suppresses the ENF, thus allowing single photon sensitivity.

Nüvü™'s ultra-sensitive cameras successfully operate in PC mode thanks to their high EM gains and minimal background noise. Although attaining large EM gains is simple, the electron-multiplying process entails more clock-induced charges (CIC), a dominant EMCCD noise source. The innovative electronics driving HNü cameras virtually eliminates CIC and lowers the total background signal while providing the highest gain on the market. The results: better data in low lighting conditions.

TYPICAL CHARACTERISTICS		HNÜ128[AO]
Maximum available EM gain (linear or PC mode):		5000
Readout noise through: EM channel with electron multiplication		< 0.1ē @ 20 MHz
Vertical clock speed	EM	0.1 – 0.5 µs
Dark current[6,7] (All operating modes)		0.02 ē/pixel/s
Clock-induced charges[8]		0.005 ē/pixel/frame
Charge transfer efficiency[9]		> 0.999980
Single photon detection probability (EM gain = 5000)		> 91%
Imaging area		128 × 128 pixels 24 µm × 24 µm pixel area 3.1 mm × 3.1 mm effective area

Table 4 HNü128[AO] Specific Characteristics

PHOTON COUNTING PERFORMANCES COMPARISON

- HNü128 (All Nüvü Camēras specifications measured in IMO.)
- Best achievable performance with other EMCCD cameras

(Other manufacturers do not specify the mode of operation – IMO or NIMO – used to measure one specific characteristic. These are two mutually exclusive EMCCD operation modes whose benefits cannot be combined.)

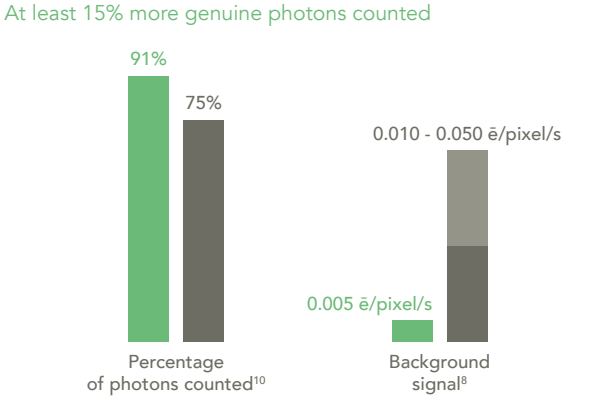


Figure 2 h·nü 128 benefits for photon counting

QUALITY PRIORITY

All parts are treated in compliance with high vacuum requirements, including all metal sealed in a Class 10,000 cleanroom to ensure the best cooling performances without maintenance. Nüvü Camēras uses at least λ/10 quality windows, essential for optimal image quality.

COMPUTER REQUIREMENTS:

› Communication interface: PCIe Camera Link (min. 4X)

› Operating system: Windows (XP, 7 & 10), Linux

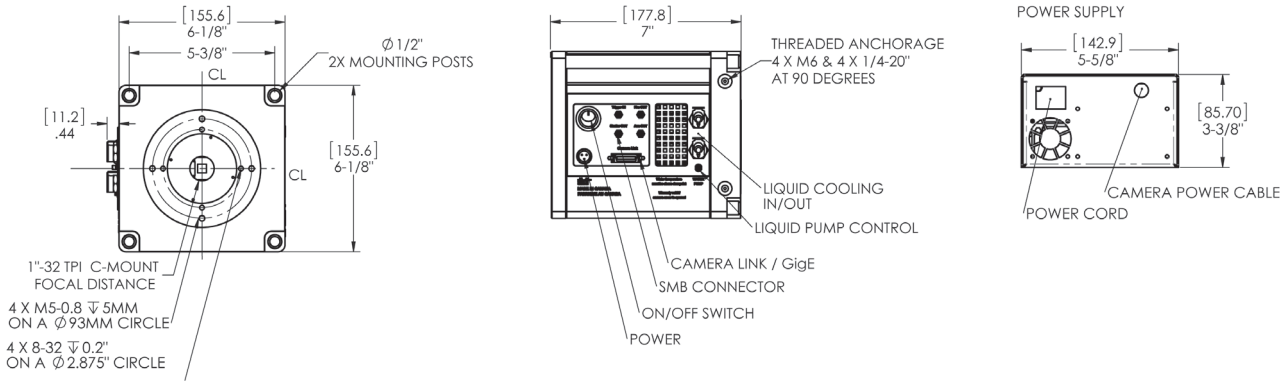
CAMERA ENVIRONMENT:

› Operating temperature: 0°C to 30°C

› Humidity: < 90 % (non-condensing)

› Power Input: 100 – 240 V, 50 – 60 Hz, max. 3 A

Technical drawings



1 Liquid cooling temperature of 16°C is considered sufficient.

2 As per the EMCCD detector manufacturer's datasheet. Other configurations may exist.

3 Minimum 25 ns exposure time available in controlled illumination conditions due to pixels clearing prior to readout.

4 Optical mask not included.

5 Horizontal binning does not influence maximum acquisition rates in EM mode at 10 and 20 MHz pixel rates.

6 These numbers may slightly vary depending on the EMCCD detector.

7 Dark current measured at -60°C.

8 Expected signal level at an EM gain of 1000 at -60°C and maximum frame rate in continuous exposure at 10 MHz.

9 Mean horizontal charge transfer efficiency measured with an EM gain of 1000 at -60°C and 10 MHz readout rate.

10 Detected events with signal 5 times greater than readout noise in photon counting mode. Measured data.

Typical Quantum Efficiency

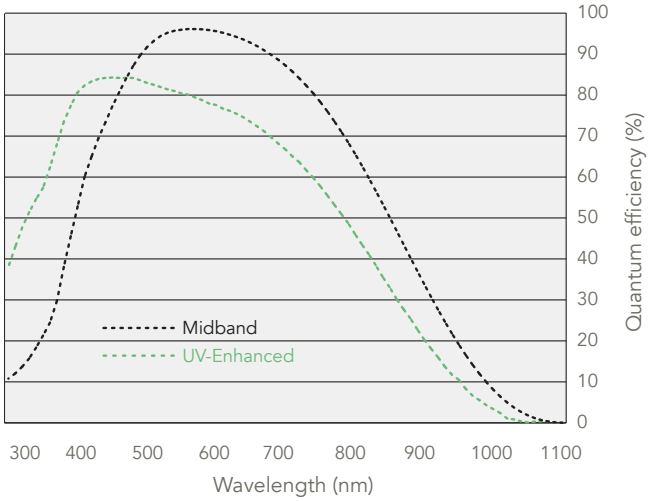


Figure 3

Typical spectral response as a function of wavelength, as measured by the EMCCD detector manufacturer

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HNü 128[AO] Specification Sheet 1.2

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