OUTSTANDING SNR THANKS TO:

- Stabilized on-chip thermoelectric air cooling down to $-60 \pm 0.01 \, ^\circ C$ 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

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**Figure 1**

$h \cdot \nu$128\textsuperscript{AO} dark frames mean signal as a function of exposure. Data measured at 10MHz with an EM gain of 1000 at -60\:\textdegree\:C.
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 128AO**

### Characteristics

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digitzation</td>
<td>16 bits</td>
</tr>
<tr>
<td>Electron-multiplying gain</td>
<td>1 - 5000</td>
</tr>
<tr>
<td>Selectable stabilized cooling temperature of EMCCD at maximum full frame readout of 20 MHz</td>
<td>-70°C via liquid cooling¹, -60°C via air cooling²</td>
</tr>
<tr>
<td>On-chip temperature stabilization</td>
<td>± 0.01°C</td>
</tr>
<tr>
<td>Quantum efficiency</td>
<td>&gt; 90% at 600 nm (see Figure 3)</td>
</tr>
<tr>
<td>EM register pixel well depth²</td>
<td>800 kē</td>
</tr>
<tr>
<td>Spectral range</td>
<td>250 - 1100 nm</td>
</tr>
<tr>
<td>Triggering</td>
<td>Internal or external Selectable signal polarity</td>
</tr>
<tr>
<td>Exposing time resolution</td>
<td>4 ns</td>
</tr>
<tr>
<td>Exposing time range³</td>
<td>25 ns - days</td>
</tr>
<tr>
<td>Timestamp resolution</td>
<td>4 ns</td>
</tr>
</tbody>
</table>

Table 1 HNü128AO Characteristics and Specifications

### Features

**Features**

- EM gain range of 1 – 5000
- Lowest clock-induced charges levels (CIC)
- Patented technology optimized for true photon counting
- Highest horizontal charge transfer efficiency
- Robust cooling performance
- Highest quantum efficiency
- Pixel readout rate up to 20 MHz
- Time stamping
- mROI
- Cropped-sensor mode

**Benefits**

- Lowest effective readout noise
- Unmatched single photon detection capabilities
- Highest SNR as a result of lowering the CIC, the dominant noise source of EMCCDs
- Linear and photon counting modes are available in EM operation
- Clearer images
- No pixel leaking
- Negligible dark noise at full frame rate
- Superior charge transfer efficiency
- Best sensitivity available thanks to back-illuminated grade 1 EMCCD detector (see Figure 3)
- Fastest acquisition speed for a 128 x 128 EMCCD camera
- High-precision time-labelling of every acquisition
- GPS input for absolute time tagging (optional)
- Select multiple customizable regions of interest on the detector to increase acquisition rates
- Faster acquisition rates for a region of interest by masking part of the EMCCD detector³
- Greater acquisition versatility using customizable size and position for the cropped region of interest

Table 2 HNü AO Features and Benefits
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.

FASTER FRAME RATES FOR SENSITIVE IMAGING

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

<table>
<thead>
<tr>
<th>BINNING</th>
<th>REGION OF INTEREST</th>
<th>128 × 128</th>
<th>64 × 64</th>
<th>32 × 32</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 × 1</td>
<td></td>
<td>1004</td>
<td>1838</td>
<td>3144</td>
</tr>
<tr>
<td>1 × 2</td>
<td></td>
<td>1814</td>
<td>3107</td>
<td>4826</td>
</tr>
<tr>
<td>1 × 4</td>
<td></td>
<td>3035</td>
<td>4725</td>
<td>6548</td>
</tr>
<tr>
<td>1 × 8</td>
<td></td>
<td>4536</td>
<td>6316</td>
<td>7857</td>
</tr>
<tr>
<td>1 × 16</td>
<td></td>
<td>5892</td>
<td>7391</td>
<td>8463</td>
</tr>
<tr>
<td>1 × 32</td>
<td></td>
<td>6608</td>
<td>7634</td>
<td>8277</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>TYPICAL CHARACTERISTICS</th>
<th>HNÜ128AO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum available EM gain (linear or PC mode):</td>
<td>5000</td>
</tr>
<tr>
<td>Readout noise through: EM channel with electron multiplication</td>
<td>&lt; 0.1 ė @ 20 MHz</td>
</tr>
<tr>
<td>Vertical clock speed</td>
<td>EM 0.1 − 0.5 μs</td>
</tr>
<tr>
<td>Dark current (All operating modes)</td>
<td>0.02 ė/.pixel/s</td>
</tr>
<tr>
<td>Clock-induced charges (EM gain = 5000)</td>
<td>0.005 ė/pixel/frame</td>
</tr>
<tr>
<td>Charge transfer efficiency</td>
<td>&gt; 0.999980</td>
</tr>
<tr>
<td>Single photon detection probability</td>
<td>&gt; 91%</td>
</tr>
<tr>
<td>Imaging area</td>
<td>128 × 128 pixels 24 μm × 24 μm pixel area 3.1 mm × 3.1 mm effective area</td>
</tr>
</tbody>
</table>

Table 4 HNü128AO 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.)

At least 15% more genuine photons counted
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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HNū 128© Specification Sheet 1.2
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