NIRvana® HS

SWIR For Science

- Unbeaten Signal to Noise Ratio
- Deep Cooling for Long Exposures
- High Temporal Resolution: 250fps
- Cold Shielding to Minimise Scene Noise

What Makes Scientific Quality SWIR Cameras?

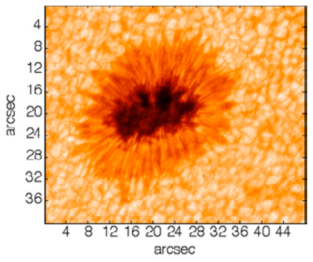
With Scientific Imaging comes unique challenges. Light levels are often low, image quality requirements are high, and reliability is paramount.

The NIRvana® range of Scientific InGaAs cameras from Teledyne Princeton Instruments is specifically designed to meet the demanding requirements of scientific imaging.

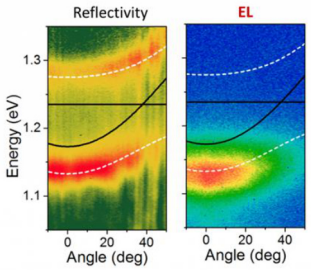
With sensitivity often the primary requirement for scientific imaging, **the NIRvana range uses large pixels, high quantum efficiencies and unbeaten low dark current noise to provide industry-leading signal to noise ratios**. Combined with this is the incredible image quality achieved through advanced pixel correction algorithms, overcoming the inherent challenges of InGaAs sensors.

Camera noise sources are not alone in infrared imaging. Thermal photons from the scene and from the camera housing are ever-present, conveying background noise. The NIRvana series uses integrated cold shielding to keep these photons, and hence this unwanted background noise out of images.

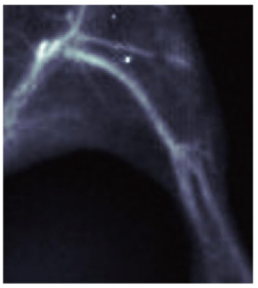
High speeds and short minimum exposure times provide the versatility required for scientific imaging. From whole animal imaging to spectroscopy of nanomaterials, the NIRvana range has a solution for your application.



Sunspot Imaging



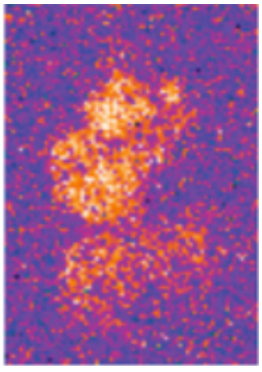
Imaging & Spectroscopy of Nanomaterials



In vivo *Imaging*

Further Benefits of the NIRvana HS:

- High Dynamic Range with >550,000e- Full Well Capacity
- Air cooling for simplicity, or liquid cooling for vibration-sensitive applications
- Lifetime Vacuum Guarantee
- Imaging and spectroscopy possible within one powerful, intuitive software package



Singlet Oxygen Imaging

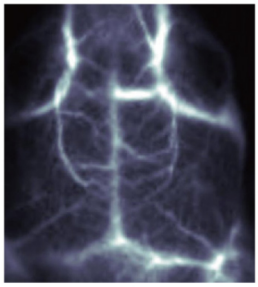
NIRvana Application Highlights

NIRvana® has a peerless scientific pedigree with **10 publications in Nature journals using NIRvana® cameras since 2017**. Whatever your scientific interest, and whether your research takes place in a university lab or in industry, the NIRvana range of cameras is there to deliver the performance you need.

NIRvana cameras cover a massive range of application areas. Below are some comments shared with us by researchers using NIRvana in their experiments.

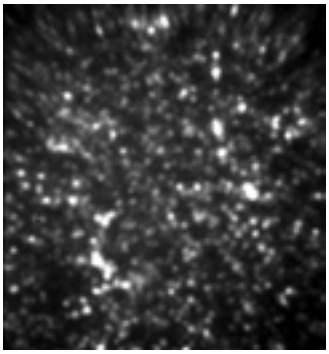
- Nanotube fluorescence
- Small-animal imaging
- Nondestructive testing
- Semiconductor analysis
- NIR probe development
- NIR-II imaging
- NIR spectroscopy
- 1064 nm Raman spectroscopy
- Astronomy (J band, H band)
- Adaptive optics
- Low-light / night vision
- Laser-illumination imaging

Deep Penetration *in vivo* Imaging in NIR-II



"The NIRvana 640 is highly sensitive, with a high signal-to-noise ratio, providing clear structural information about the blood vessels."

Prof. Fan Zhang, & Dr. Zhang Hongxin,
Department of Chemistry, Fudan University, China



Measuring Spectra of Single Quantum Dots

"The unprecedented long integration times and low dark counts [of the NIRvana LN] enabled single-nanocrystal spectral experiments, which cannot be achieved with conventional InGaAs detectors for these dots."

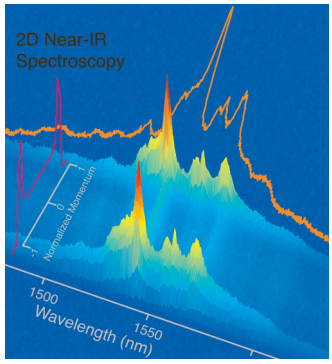
Dr. Han Htoon,
Center for Integrated Nanotechnologies, Los Alamos National Laboratory

Energy-Momentum Resolved Spectroscopy

"Unlike other InGaAs 2D detectors we tested, the TE cooling and background subtraction features have allowed us to easily acquire long exposures to resolve photoluminescence from very dilute emitter samples."

Prof. Rashid Zia,

School of Engineering, Brown University, USA



TELEDYNE IMAGING
Everywhereyoulook™

What Sets NIRvana Apart

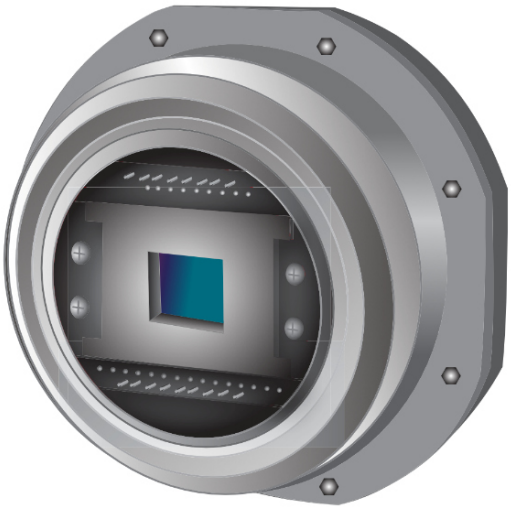
Unparalleled Thermal Management

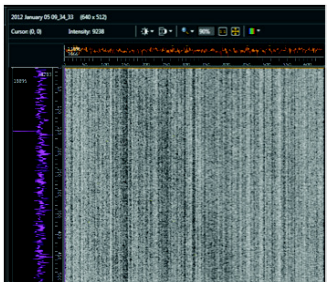
The exemplary thermal management and lifetime vacuum guarantee of NIRvana cameras demonstrate Teledyne Princeton Instruments' 40 years of experience in cooling technology.

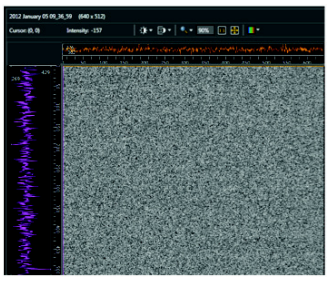
The NIRvana HS's multi-stage thermo-electric cooling (TEC) reaches -55 °C with water cooling, reducing dark current noise to only 500e-/p/s: an order of magnitude lower than industrial cooled SWIR cameras.

The low temperatures achieved, and as importantly the stability with which they are maintained, provide the lowest noise for long exposures and vital baseline stability for quantitative measurements[1].

Our all-metal hermetic vacuum seals are completely maintenance-free. The NIRvana series are the only SWIR cameras guaranteed against moisture or loss of vacuum for the entire lifetime of the camera.







Optimum Image Quality

InGaAs sensors are subject to a number of factors that affect image quality. Individual pixel defects, star defects, column-to-column variations and multiple pixel clusters are all universal features of InGaAs sensors. Without careful correction, these defects can throw off analysis routines and reduce image quality.

The NIRvana range of cameras have unique capabilities for dealing with these defects powerfully and transparently[2], providing a scientific image quality and imaging workflow that provides data you can trust.

[1] - For further information, please see our NIRvana Thermal Management Technical Note: www.princetoninstruments.com/nirvana/thermal

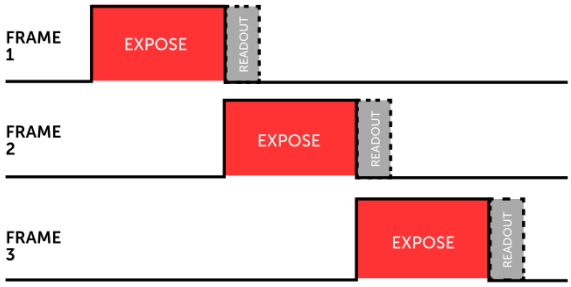
[2] - For further information, please see our NIRvana Image Corrections Technical Note: www.princetoninstruments.com/nirvana/corrections

High Speed & 100% Duty Cycle

The NIRvana HS is capable of blisteringly high speeds, with frame rate at the full 640x512 of up to 250fps.

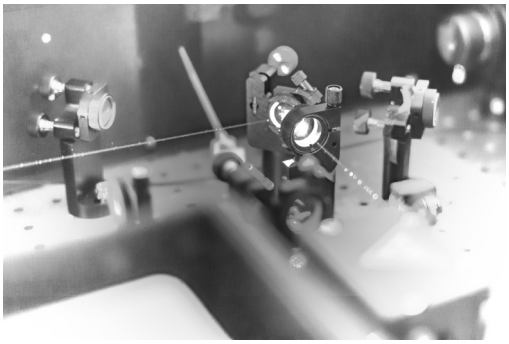
Using regions of interest can significantly boost speed, with 200x200 reaching 1200fps. Multiple regions of interest can also be used.

Further, Integrate While Read (IWR) mode allows readout to occur simultaneously with acquisition of the next frame, constantly exposing the camera to light and maximizing collection efficiency.

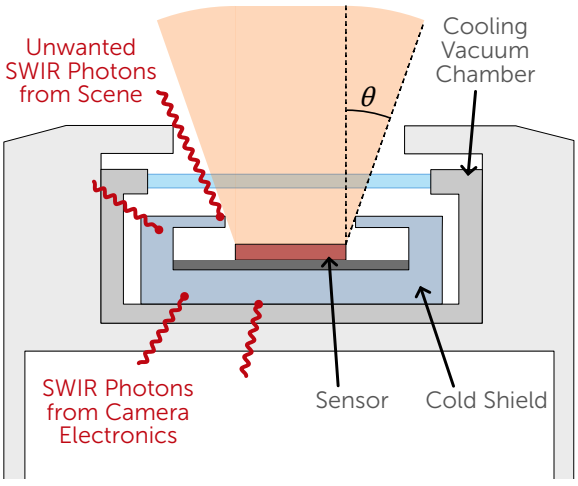


Integrate While Read (IWR) mode for maximum duty cycle

Minimized Scene Noise



A unique challenge in infrared imaging is that SWIR photons are, in fact, everywhere. We aren't of course able to see them to allow us to easily trace and eliminate background photon sources. But all background light contributes background noise, which can in many cases outstrip camera-based noise sources depending on the severity. Indeed, due to blackbody radiation, all room temperature objects are constantly emitting SWIR photons, as are the electronic circuits and housings of SWIR cameras.



The NIRvana range of cameras features Cold Shielding. This is a physical barrier that blocks unwanted photons outside a specified cone angle, θ, as shown in the diagram opposite. This shield is cooled to the same ultra-low temperature as the sensor leading to negligible thermal photon emission[3].

Additionally, world-leading thermal management engineering isolates thermal photons from camera electronics and maintains a lower camera housing temperature, reducing further the possibility of unwanted photon detection.

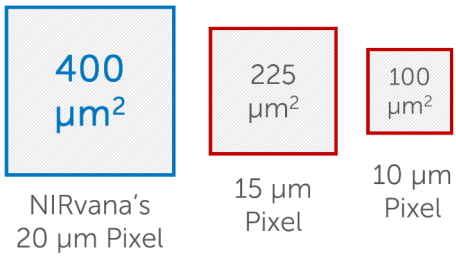
[3] - For further information, please see our NIRvana Cold Shielding Technical Note: www.princetoninstruments.com/nirvana/shielding

Unbeaten Sensitivity

The NIRvana range of cameras represent the height of SWIR sensitivity.

Large Pixels Collect More Light

As sensitivity scales with pixel area, the 20 µm pixels used by the NIRvana range of cameras provide 1.8x the light collection ability of a 15 µm pixel, and 4x that of a 10 µm pixel.

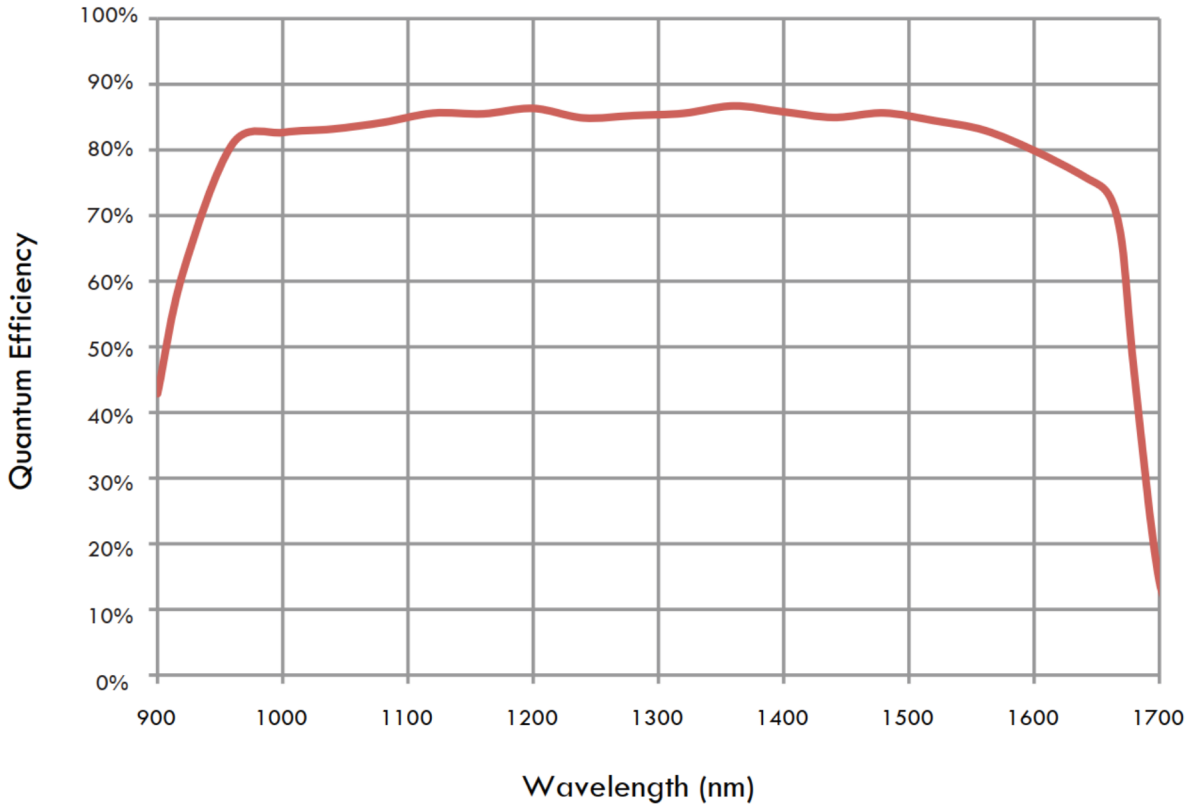


Low Noise Operation

Dark Current Noise is typically the largest noise source in InGaAs imaging. Due to the low cooling temperatures achieved, dark current noise is drastically reduced in the NIRvana range of cameras. Combined with low read noise, the NIRvana range provides incredible signal to noise performance.

High Quantum Efficiency

The NIRvana HS achieves >80% quantum efficiency across an incredibly broad range, from 950 to 1600nm, enabling low light imaging across the NIR-II / SWIR region.



Combining These Factors: Signal to Noise Ratio

What is the relative importance of pixel size, quantum efficiency, dark current, read noise, and all the other factors above? The answer depends upon your typical exposure time, background light level, and expected photon budget. But all the complexity can be set aside: **the Signal to Noise Ratio represents the entire balance of factors with one single number**[4]. Equation 1 shows how this is calculated:

$$SNR = \frac{Signal}{Total\ Noise} = \frac{I_s \times t_{exp} \times d_{pixel}^2 \times QE}{\sqrt{\left((I_s + I_b) \times t_{exp} \times d_{pixel}^2 \times QE\right) + \left(\sigma_d \times t_{exp}\right) + \sigma_r^2}}$$

Equation 1: Signal to Noise Ratio for InGaAs Cameras. The first term in Total Noise represents total photon shot noise.

I_s = Irradiance, i.e. incoming signal in (photons / second / μm²)
t_{exp} = Exposure time (seconds)
d_{pixel} = Pixel size (μm)
QE = Quantum Efficiency at the detection wavelength of interest
I_b = Background irradiance, i.e. all background signal (photons / second / μm²)
σ_d = Dark current (e- / pixel / second)
σ_r = Read noise (e-)

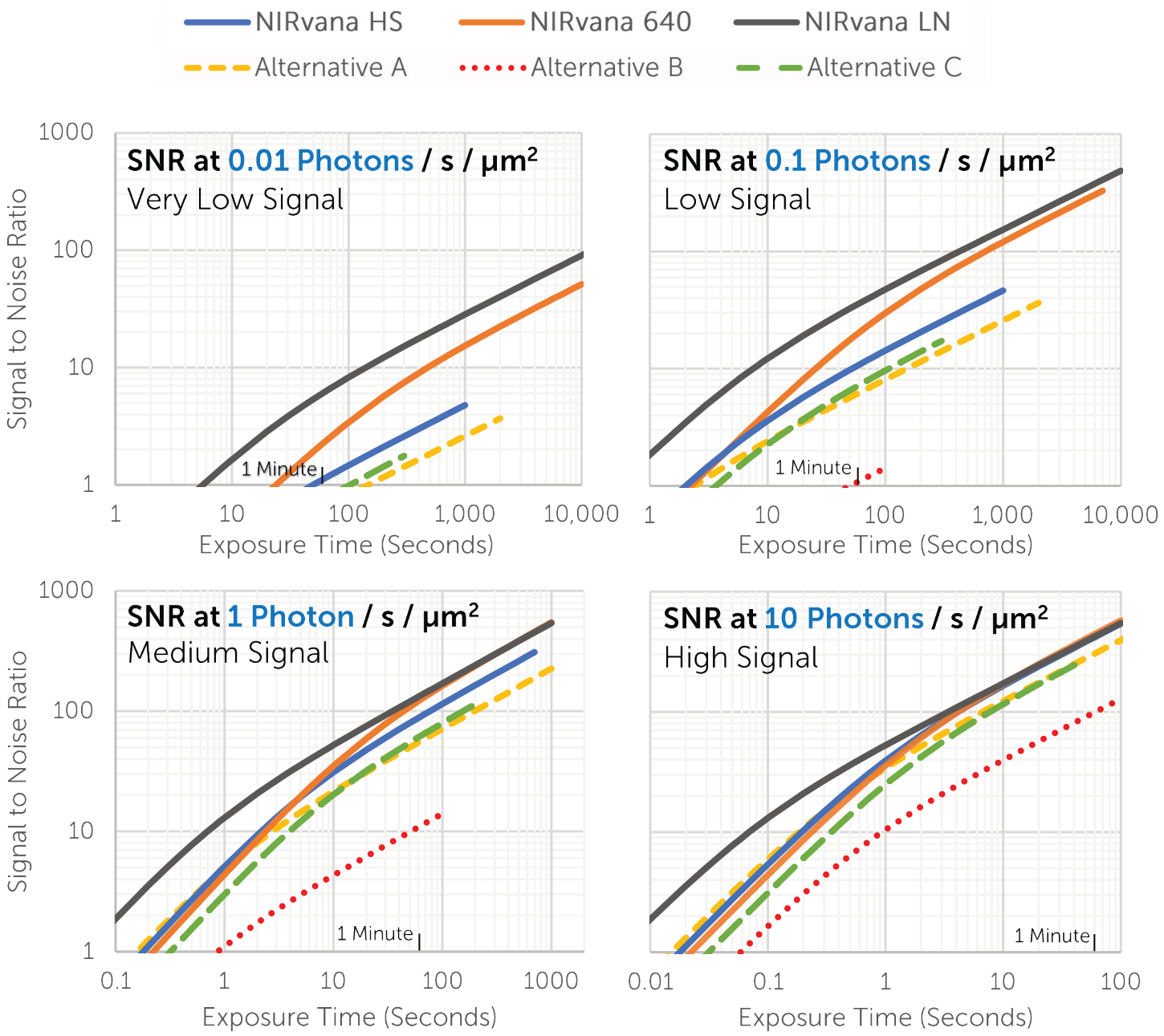
The graphs on the following page show the calculated signal to noise ratios of the three NIRvana cameras compared to three representative alternative cameras. For the calculation the contribution of scene noise from the experimental setup, I_b, is ignored.

Incoming signal is explored over 3 orders of magnitude from 'high' signals of 10 photons / s / μm², which would equate to 4000 photons per pixel per second for the NIRvana cameras, to 'very low' signals of 0.01 photons / s / μm², for which very long exposure times would be necessary to achieve adequate signal to noise. The graphs are shown up to the point where pixel saturation would occur through the combination of collected signal and dark current.

The dominance of low dark current and large pixel sizes is evident; **the NIRvana camera range offers superior sensitivity in practically every case.** For the alternative cameras, due to their higher dark current, saturation of the pixel is frequently seen before an adequate signal to noise ratio can be achieved.

In real-life imaging situations, scene noise that we discounted here will be present in almost all cases. The presence of **cold shielding** in the NIRvana range of cameras will then be very likely to **significantly increase the NIRvana cameras' lead in signal to noise ratio**, compared to alternatives without cold shielding which would suffer from greater background noise I_b.

[4] - For further information, please see our NIRvana Signal and Noise Technical Note: www.princetoninstruments.com/nirvana/signalandnoise



Camera	Read Noise	Dark Current	QE	Pixel Size	Full Well Cap.
Alternative A	30 e-	600 e-/p/s	90%	15 µm	1400 ke-
Alternative B	50 e-	4000 e-/p/s	90%	10 µm	450 ke-
Alternative C	55 e-	300 e-/p/s	80%	15 µm	110 ke-

Signal to Noise Ratio graphs for different incident signal levels, defined in photon flux, in photons per second per square micrometer incident on the pixel. Each SNR line ends at pixel saturation. The NIRvana range of cameras are shown in comparison to three alternative cameras representative of cameras on the market, with specifications given in the table above. Theoretical calculation based on specification sheet values.

NIRvana HS Specifications

Feature	NIRvana HS	
Sensor	2D InGaAs FPA	
Imaging format	640 x 512	
Active area	12.8 mm x 10.24 mm	
Pixel size	20 µm x 20 µm	
Optical interface	C-mount; Spectrometer mount	
Spectral response	0.9 µm to 1.7 µm	
Quantum efficiency	>80% from 1 µm to 1.6 µm; peak QE is 85%	
Pixel well capacity (e-)	High Gain ≥ 40,000	High Capacity ≥ 550,000
Nominal gain (e-/count)	1	11
Typical system read noise (e-)	<60 (High Gain)	
Response nonlinearity	<1% (High Gain)	
Cooling temp. @ 20°C ambient	-55°C liquid, -50°C air	
Cooling method	Air only, liquid only, or a combination of air and liquid	
Dark current (e-/p/s)	500 e-/p/s @ -55°C sensor temperature, 800 e-/p/s @ -50°C	
Thermostating precision	±0.05°C across entire temperature range	
Cold shield[5]	f#/1.5; Light cone angle θ = 20°	
Output interface	USB 3.0	
Digitization	16 bits	
Frame rate @ 640 x 512	250 fps	
Region of interest	Multiple regions of interest with increase in frame rate	
ROI frame rate	725 fps @ 300 x 300; 1200 fps @ 200 x 200	
Shutter	Global shutter	
Readout modes	Integrate Then Read (ITR), Integrate While Read (IWR)	
Exposure time	<2 µs to 1 minute	
Window material	Fused silica (AR coated)	
Operating temperature	0°C to +30°C	
Weight	7.2 lbs. (3.3 kg)	
Power supply	12V DC ± 10%	
Dimensions (C-mount) (L x W x H)	7.25" x 4.5" x 4.5" (184 mm x 114 mm x 114 mm)	
Certification	CE	

[5] - See page 5 for explanation of Cold Shield specifications

All specifications are typical performance and are subject to change. NOTE: Export of this camera outside of the United States is prohibited by law unless accompanied by a valid Export License as issued by the United States Department of Commerce.

Software Support & Integration

LightField® Software allows for complete control of all Teledyne Princeton Instruments cameras and spectrometers on an easy to use platform. LightField software also includes simple image post-processing software and a built-in, smart math engine to obtain the most from acquired data.

Teledyne Princeton Instruments LightField® provides **imaging and spectroscopy** within one powerful and versatile software package.

LightField® also makes integration easy with LabVIEW® (National Instruments), MATLAB® (MathWorks) or Python®, allowing you to command the software directly from whichever program you prefer.

For those requiring a custom solution, the PICAM API and SDK, from Teledyne Princeton Instruments offer complete control over all cameras, available for all 64-bit Windows and Linux systems.

Teledyne Princeton Instruments: Part of Teledyne Imaging

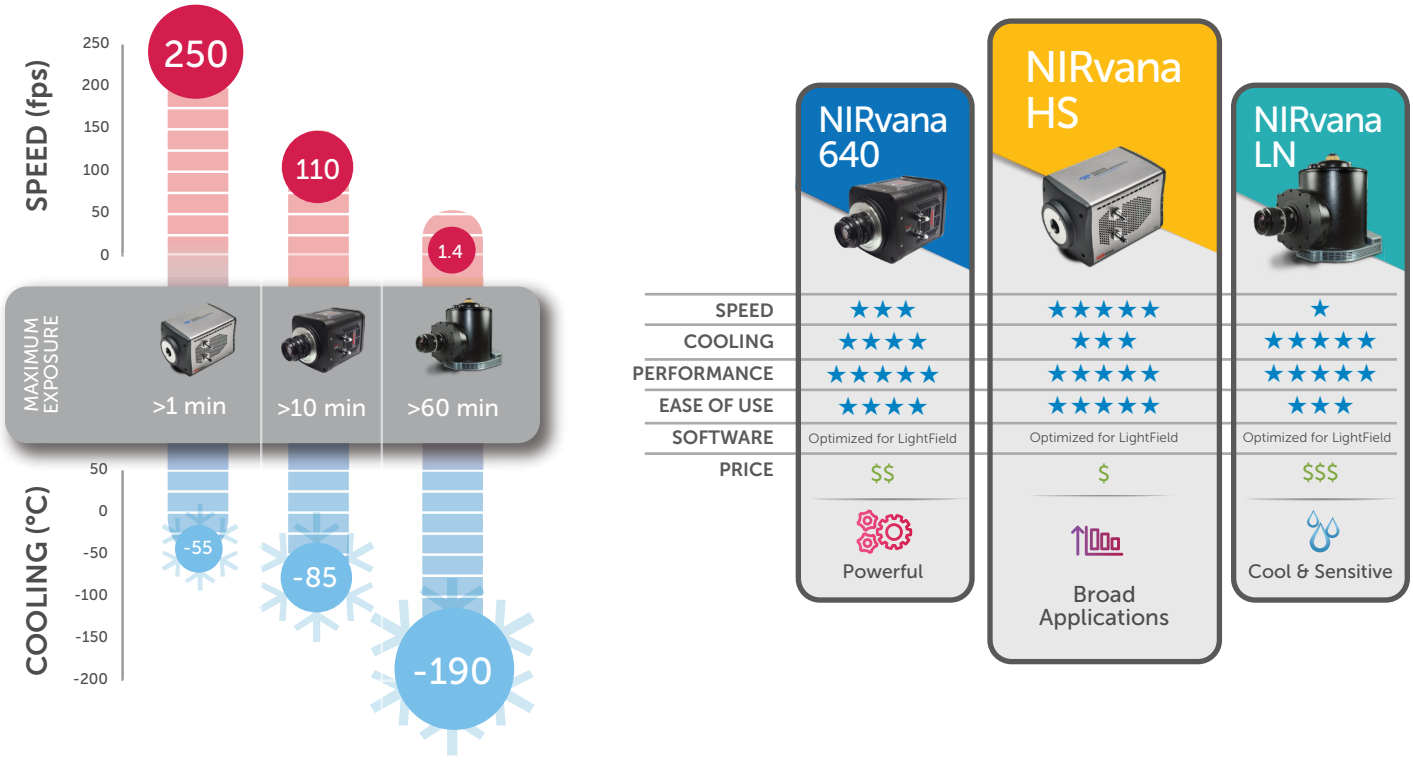
Teledyne Imaging is a group of leading-edge companies aligned under the Teledyne umbrella. Teledyne Imaging forms an unrivaled collective of expertise across the spectrum and decades of experience. Individually, each company offers best-in-class solutions. Together, they combine and leverage each other's strengths to provide the deepest, widest imaging and related technology portfolio in the world.

Teledyne Princeton Instruments (TPI), a business unit of Teledyne Digital Imaging US, Inc, designs and manufactures high-performance CCD, CMOS, ICCD, EMCCD, emICCD, and InGaAs cameras; spectrographs; and optics-based solutions for the scientific research, industrial imaging, and OEM communities. We take pride in partnering with our customers to solve their most challenging problems in unique, innovative ways.

Teledyne Princeton Instruments has a vast history of facilitating key research in many fields. Our family of NIRvana® cameras has enabled numerous scientific and commercial advances by delivering the world's best SWIR imaging performance.

The NIRvana Camera Range

*Need even more sensitivity? Consider the **NIRvana 640** or the **NIRvana LN**!*



TELEDYNE IMAGING
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NIRvana® HS

SWIR FOR SCIENCE

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NIRvana® 640 InGaAs SWIR CAMERA

For low-light NIR and SWIR imaging and spectroscopy

KEY FEATURES

- Unmatched signal-to-noise ratio for SWIR/NIR-II
- 900-1700 nm SWIR/NIR-II sensitivity with InGaAs
- Ultra-low dark current <40 e^-
- Industry-leading ultra-deep cooling without liquid nitrogen
- Hermetically sealed vacuum with lifetime guarantee
- Optimized for long exposures over 10 minutes
- Cold shielding to minimize scene noise
- Large 20 µm pixel for sensitivity
- High dynamic range with <600,000 e^- full well capacity
- Unrivaled scientific reputation with over 10 publications in *Nature* since 2017

TYPICAL APPLICATIONS

- *In vivo* imaging
- Deep tissue imaging
- Imaging and spectroscopy of nanomaterials
- Sunspot imaging
- Singlet oxygen imaging
- Quantum dot imaging
- SWIR/NIR-II probe testing

RELIABILITY

- Three-year warranty
- Lifetime vacuum guarantee

SWIR for Science

The NIRvana 640 InGaAs SWIR camera will let you see the unseen, offering incredible sensitivity in the short-wave infrared (SWIR) region from 950 nm to 1700 nm, ensuring you can collect every photon you can, and matching your challenging SWIR samples!

The biggest barrier to sensitive, low-light SWIR imaging is dark current. Thanks to sustained deep cooling, the NIRvana 640 offers an incredibly low dark current of only 40 e^-/p/s, enabling long exposures. Along with its low noise, the NIRvana 640 features a high >85% peak QE, large 20 µm pixels, and a proprietary cold shield, resulting in a highly sensitive InGaAs camera with proven scientific performance.

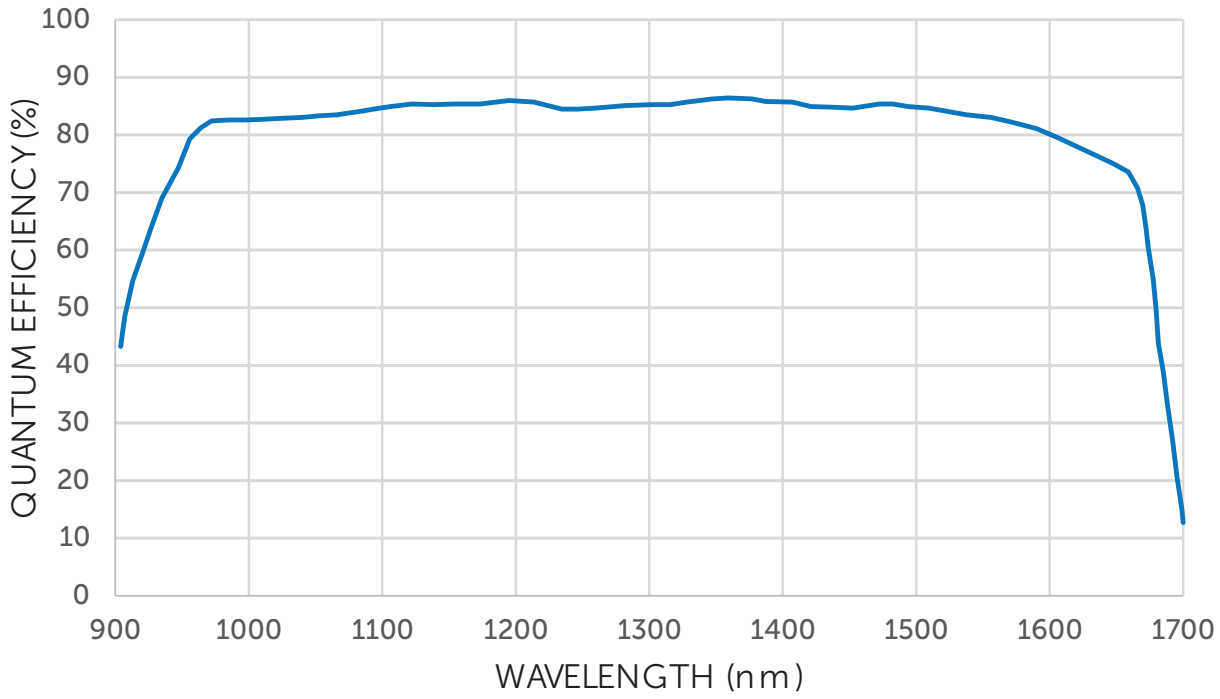
NIRvana 640 SPECIFICATIONS

SPECIFICATIONS	Camera Performance
Sensor	2D InGaAs FPA
Blemish Specification	Grade A: < 2% defects
Active Array Size	640 x 512 (0.3 megapixel)
Pixel Area	20 µm x 20 µm (400 μm^2)
Sensor Area	12.8 mm x 10.24 mm (16.39 mm diagonal)
Quantum Efficiency	> 80% from 1000-1600 nm (peak QE 85% at ~1350 nm)
Spectral Response	900 – 1700 nm
Full Well Capacity	45,000 e^- (high gain mode); 600,000 e^- (high capacity mode)
Nominal Gain	1 e^-/count (high capacity mode); 14 e^-/count (high capacity mode)
Typical Read Noise	40 e^-/p/s @ -85 °C (high gain); 150 e^-/p/s @ -80 °C (high capacity)
Response Nonlinearity (for exposures > 20 ms)	< 2% (high gain mode)
Dark Current	40 e^-/p/s @ -85 °C (high gain); 150 e^-/p/s @ -80 °C (high capacity)
Cooling Options	-85 °C air + liquid circulation (high gain); -80 °C air only (high capacity)
Thermostating Precision	±0.05 °C across entire temperature range
Cold Shield	f#/1.5; Light cone angle θ = 20°C
Optical Mount	C-Mount, Spectrometer Mount
Output Interface	GigE
Digitization	16-bit
Binning and ROI Options	Software only
Shutter	Global shutter
Exposure Time Range	< 2 µs to 10 minutes
Window Material	Fused silica (AR coated)
Operating Temperature Range	0 °C to 30 °C
Camera Weight	9.5 lbs, 4.3 kg
Camera Dimensions	187.96 x 147.32 x 147.32 mm (L x W x D)
Certification	CE

NIRvana 640 SPEED TABLES

Camera Scan Rates			
Specifications	**10 MHx**	**5 MHx**	**2 MHx**
Frame Rate	110 fps	55 fps	22 fps

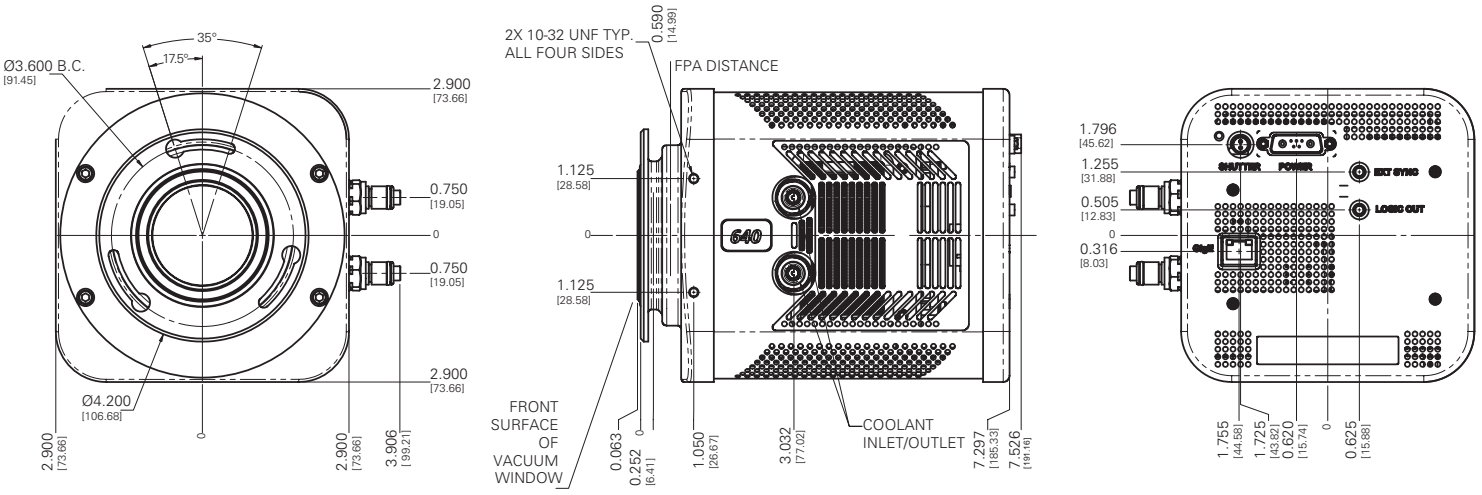
NIRvana 640 QE CURVE



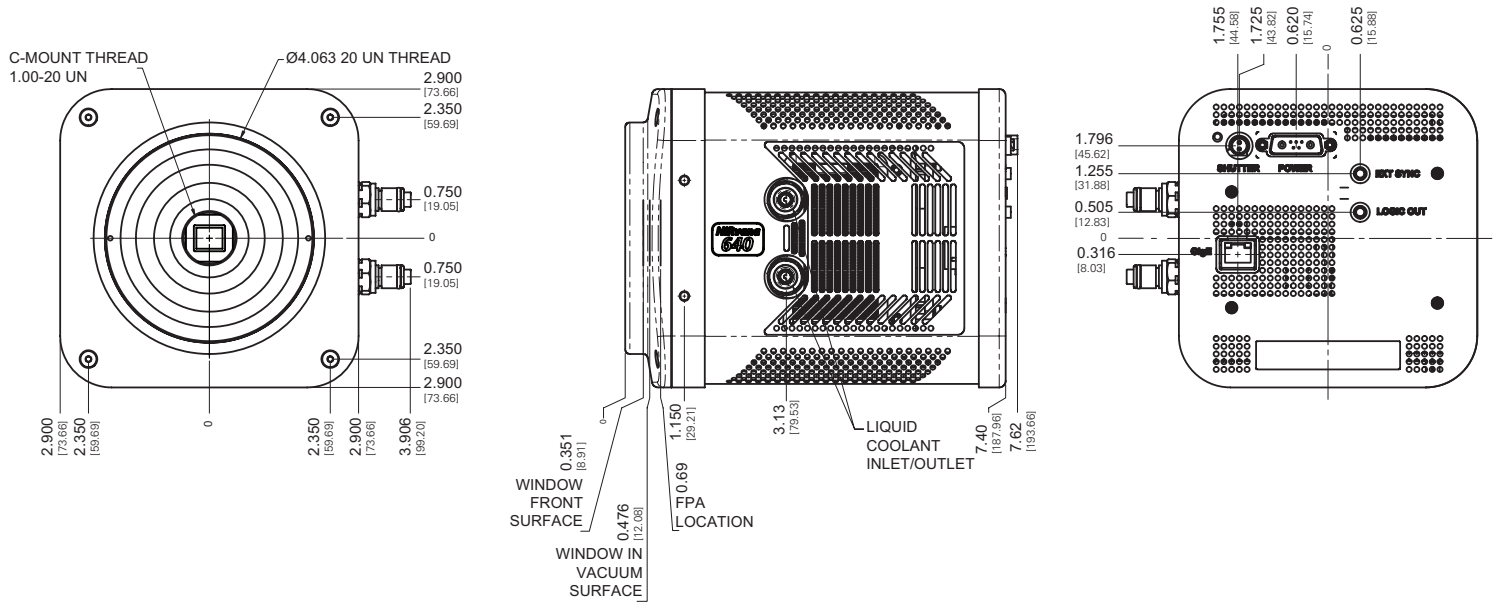
NIRVANA 640 ACCESSORIES

ACCESSORIES (Included)	ACCESSORIES (Optional)
GigE Data Cable	Additional optical adapters
Power Supply (12V/10A DC)	
PICAM drivers/software	
Quick start guide	
Performance and gain test data	

NIRVANA 640 (C-MOUNT ADAPTER) DIMENSIONAL OUTLINES (Unit: mm)



NIRVANA 640 (SPECTROMETER ADAPTER) DIMENSIONAL OUTLINES (Unit: mm)



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Revision Date: 2025 01 10

NIRvana® LN InGaSa SWIR CAMERA

KEY FEATURES

- Liquid nitrogen cooled -190 °C
- Unparalleled thermal management
- Ultra-low dark current <10 e^-
- Ultra-low read noise <15 e^-
- 850-1600 nm SWIR/NIR-II sensitivity with InGaAs
- Non-destructive readout mode for real-time monitoring
- Hermetically sealed vacuum with lifetime guarantee
- Cold shielding to minimize scene noise
- Large 20 µm pixel for sensitivity
- High dynamic range with <400,000 e^- full well capacity
- Unrivaled scientific reputation with over 10 publications in *Nature* since 2017

TYPICAL APPLICATIONS

- *In vivo* imaging
- High-speed failure analysis
- Deep tissue imaging
- Imaging and spectroscopy of nanomaterials
- Sunspot imaging
- Singlet oxygen imaging
- Quantum dot imaging
- SWIR/NIR-II probe testing

RELIABILITY

- One-year warranty
- Lifetime vacuum guarantee

Unmatched Sensitivity in SWIR Imaging with the NIRvana LN Camera

The cryogenically cooled NIRvana® LN InGaAs SWIR camera offers exceptional sensitivity in the short-wave infrared (SWIR) region from 850 nm to 1600 nm, ensuring you can collect every photon and match your challenging SWIR samples!

The NIRvana LN stands out for its liquid nitrogen cooling, providing ultra-low dark current, low read noise, large pixels, and high quantum efficiencies. If it can be seen, you can see it with the NIRvana LN. Featuring long exposure capabilities, live monitoring, and real-time adjustments, the NIRvana LN represents the pinnacle of InGaAs technology.

NIRvana LN SPECIFICATIONS

SPECIFICATIONS	Camera Performance
Sensor	2D InGaAs FPA
Active Array Size	640 x 512 (0.3 megapixel)
Pixel Area	20 µm x 20 µm (400 μm^2)
Sensor Area	12.8 mm x 10.24 mm (16.39 mm diagonal)
Quantum Efficiency	> 70% from 1150-1550 nm (peak QE 88% at ~1450 nm)
Spectral Response	850 – 1600 nm
Full Well Capacity	400,000 e^-
Nominal Gain	7 e^-/count
Typical Read Noise	15 e^-
Cooling Method	Liquid nitrogen (with >30 hour hold time)
Dark Current	10 e^-/p/s @ -190 °C
Thermostating Precision	±0.05 °C across entire temperature range
Blemish Specification	Grade A: < 2% defects
Cold Shield	f#/1.5; Light cone angle θ = 14.4°C
Optical Mount	F-Mount, Spectrometer Mount
Output Interface	GigE
Digitization	16-bit
Read Modes	Standard readout, Non-destructive readout (NDRO)
Shutter	Global shutter
Exposure Time Range	< 100 µs to > 60 minutes
Window Material	Fused silica (AR coated)
Operating Temperature Range	0 °C to 30 °C
Camera Weight	15.43 lbs, 7.0 kg (empty); 19.40 lbs, 8.8 kg (full)
Camera Dimensions	295.30 x 206.50 x 297.20 mm (L x H x W)
Certification	CE

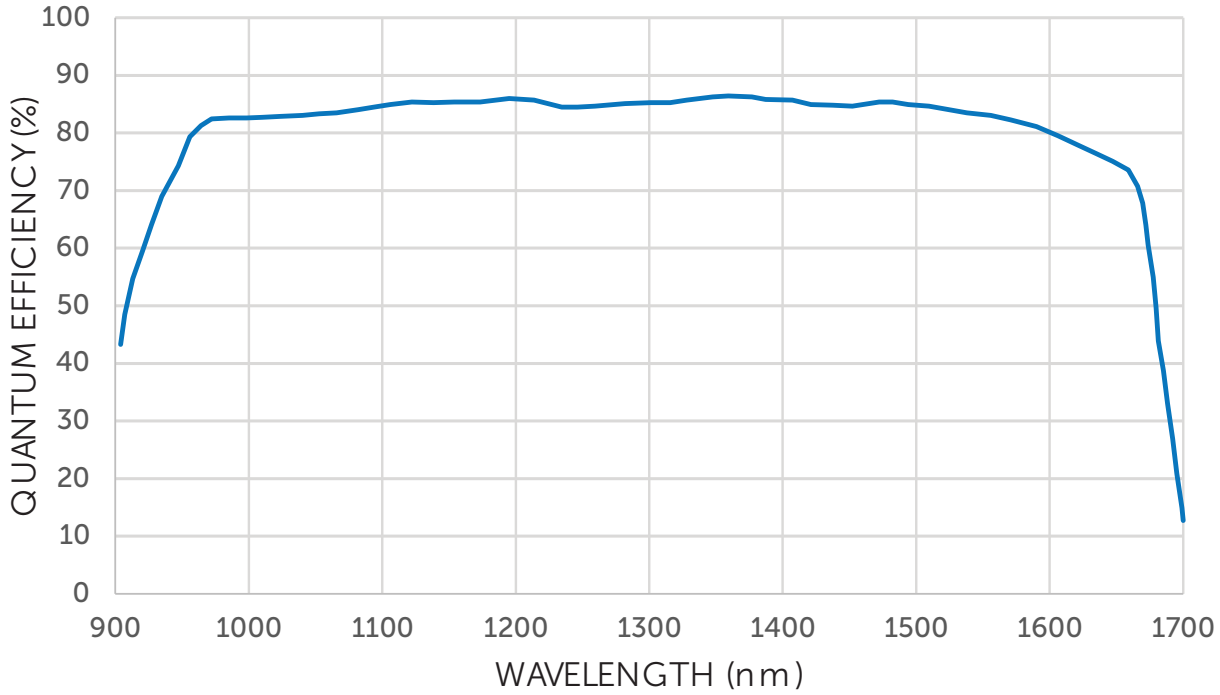
NIRvana LN SPEED TABLES

Camera Scan Rates		
Specifications	**250 kHz**	**125 kHz**
Frame Rate	2.77 fps	1.4 fps

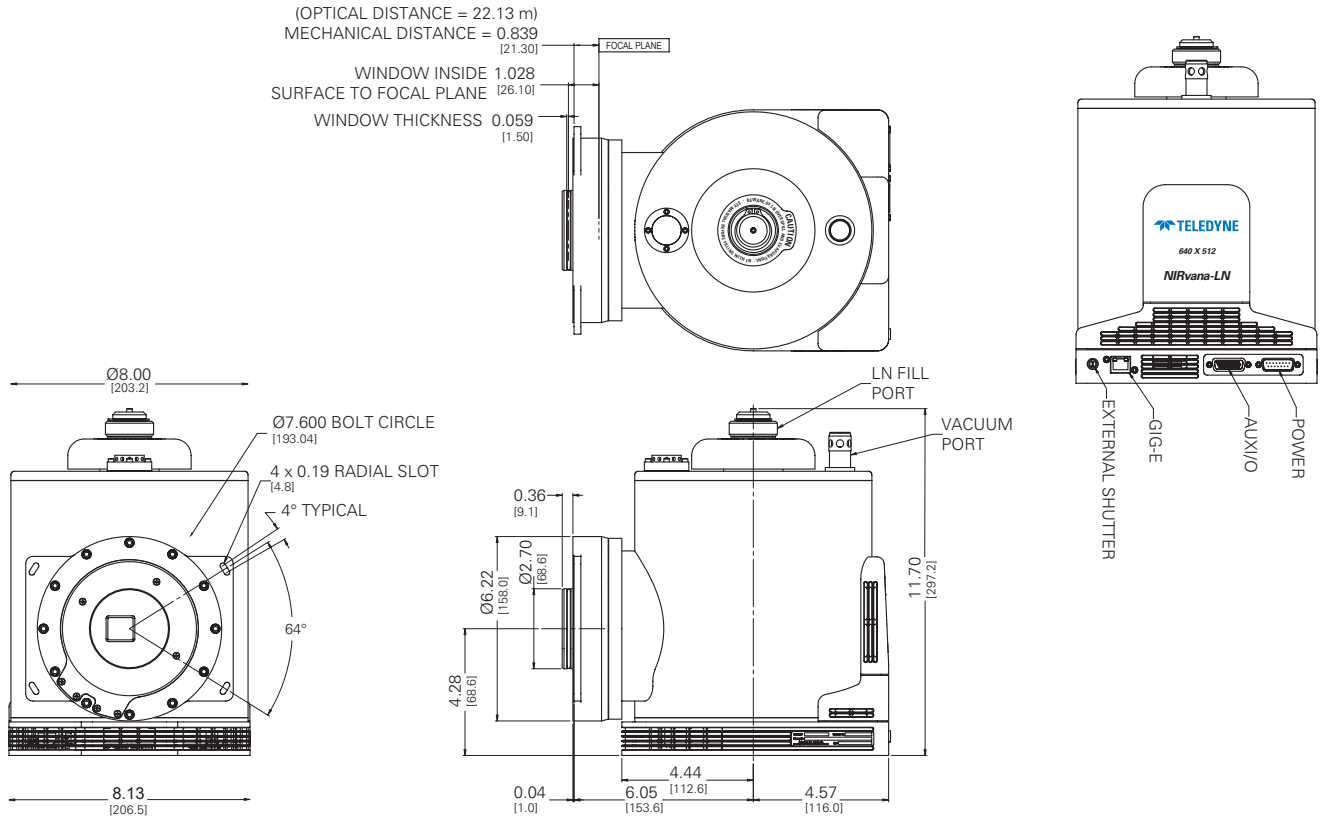
NIRvana LN ACCESSORIES

ACCESSORIES (Included)	ACCESSORIES (Optional)
GigE Data Cable	Additional optical adapters
Power Supply (12V/10A DC)	
PICAM drivers/software	
Quick start guide	
Performance and gain test data	

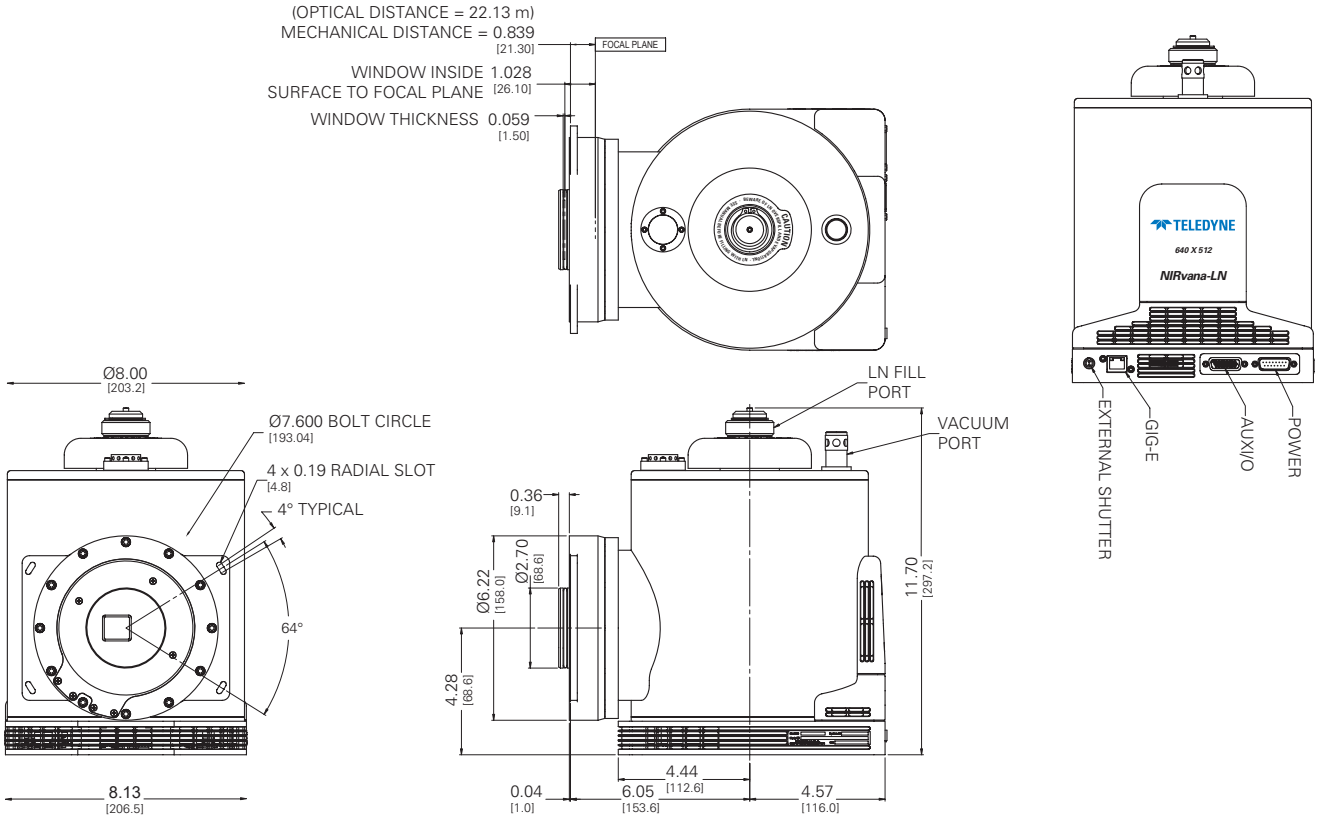
NIRvana LN QE CURVE



NIRvana LN (F-MOUNT ADAPTER) DIMENSIONAL OUTLINES (Unit: mm)



NIRvana LN (SPECTROMETER ADAPTER) DIMENSIONAL OUTLINES (Unit: mm)



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