ASTRONOMY

UV-VIS-SWIR
Cameras and Spectrographs

TELEDYNE
PRINCETON INSTRUMENTS
Everywhereyoulook™

Envision the Universe with Princeton Instruments

Who We Are

Princeton Instruments not only helps astronomers see more of the universe, we help you understand more of what you see.

Our state-of-the-art cameras, spectrometers, optics, and coatings are utilized at leading observatories around the world, providing the most innovative technologies to meet the very latest challenges.

Whether your work calls for slow-scan imaging that necessitates hours of integration or for time-resolved photometry that demands blazing fast frame rates, Princeton Instruments has the right solution!

What We Do

Over the course of six decades, we've developed and perfected many vision-expanding technologies for astronomy.

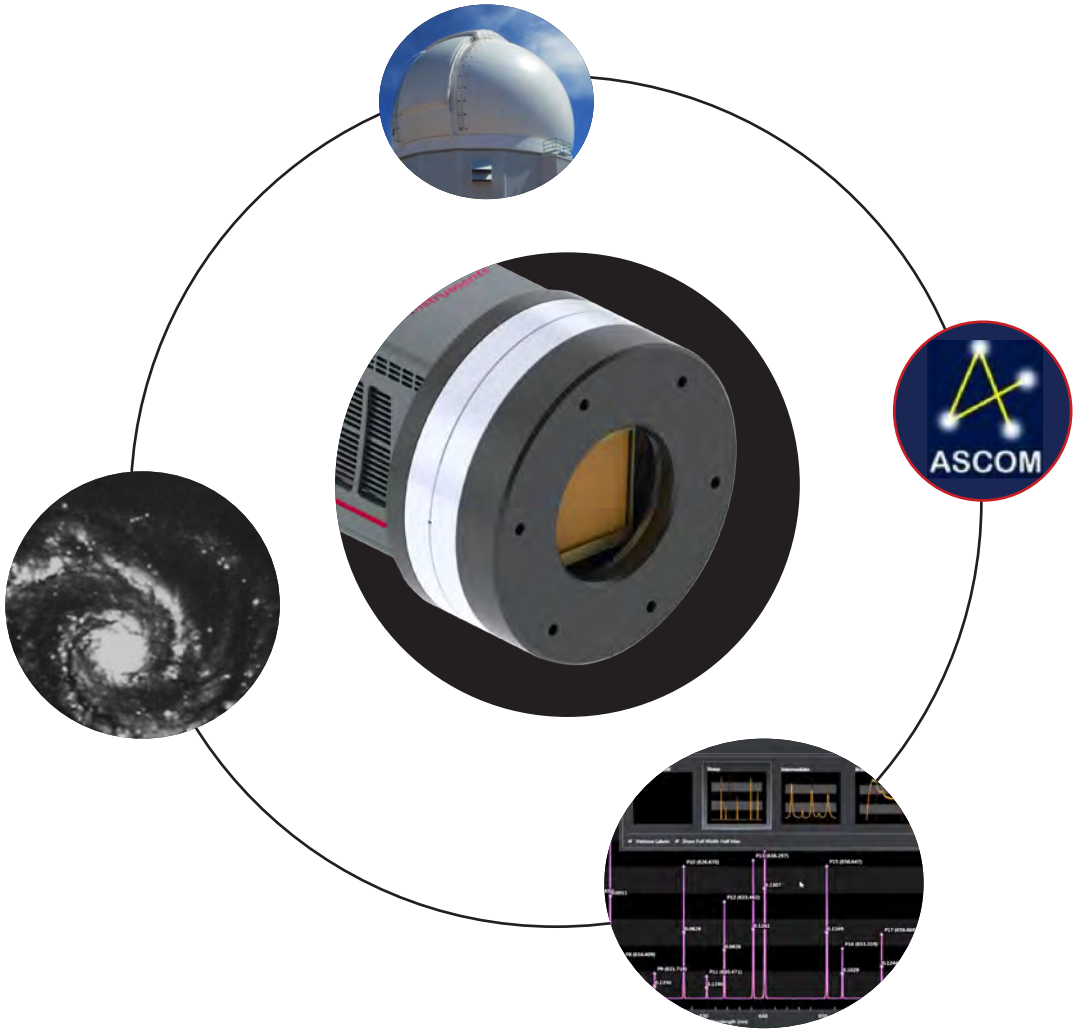
Deeper detector cooling, quicker device readout, higher spectral sensitivity over the UV-VIS-NIR-SWIR range, back-thinned CMOS and CCD sensors, InGaAs focal plane arrays, and aberration-free spectrographs are just a few of our key contributions.

We provide both off-the-shelf and customized detectors and coatings for even the most sophisticated astronomical observations.

Our innovations do not stop with hardware! Princeton Instruments offers the most comprehensive set of software tools available to the astronomy community. We make integration easy, regardless of installation size or application complexity.

We Serve You

Hundreds of Princeton Instruments cameras are being used by astronomers all over the world to enable varied and novel investigations. Recent astronomical discoveries have been astounding, and the pace of discovery is increasing.



We understand the formidable technical requirements of today's astronomers, including the need to collect, store, and analyze enormous amounts of data.

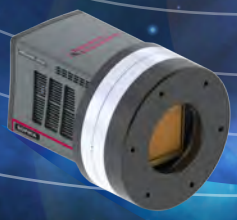
Princeton Instruments provides a complete lineup of scientific-grade cameras, spectrometers, and software for observations from VUV to SWIR!

Princeton Instruments

Advanced Solutions for Astronomical Imaging and Spectroscopy

From high-speed imaging to long exposures, ultraviolet to infrared, Princeton Instruments has you covered. Our cameras utilize the most advanced detector cooling technologies, which enable you to stare at the universe for hours, while our fast readout and high frame rates are perfect for time-resolved photometry and speckle imaging.

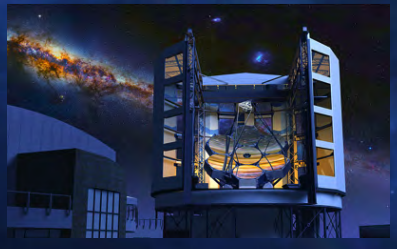
Whatever your application, Princeton Instruments has the right solution!



CCD
SOPHIA

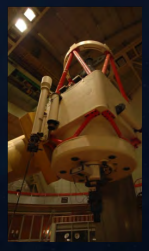
CCD
BLAZE

CCD
PIXIS



See page 35 for photo credits.


IsoPlane
Spectrometers
IsoPlane
SWIR
NIRvana LN
SWIR
NIRvana
Kuro
BI-sCMOS
KURO
ProEM
EMCCD
ProEM-HS
PyLoN
CCD
PyLoN


INNOVATION

One way in which Princeton Instruments helps keep astronomers at the forefront of discovery is by continually introducing and improving detector and optical technologies. Our core capabilities encompass the design and manufacture of scientific-grade camera systems, spectrographs, software, optics, and coatings. Expertise gained through decades of experience allows us to offer technological innovations that are reliable as well as remarkable.

Camera Sensors

CCD

Princeton Instruments offers astronomers a number of distinct sensors from which to choose. Primary CCD types include thinned back-illuminated CCDs and back-illuminated deep-depletion CCDs. Our latest BLAZE cameras feature "super-depleted" back-illuminated sensors for 75% quantum efficiency at 1000 nm.

EMCCD

Electron-multiplying CCDs with back-illuminated architectures are engineered to address the challenges of ultra-low-light imaging applications at high speed without the use of external image intensifiers. They are capable of single-photon detection.

BI-sCMOS

Aided by the latest fabrication technology, scientific CMOS cameras with back-illuminated sensors deliver 95% peak quantum efficiency and very low read noise, providing a legitimate alternative to CCD cameras for time-resolved photometry applications.

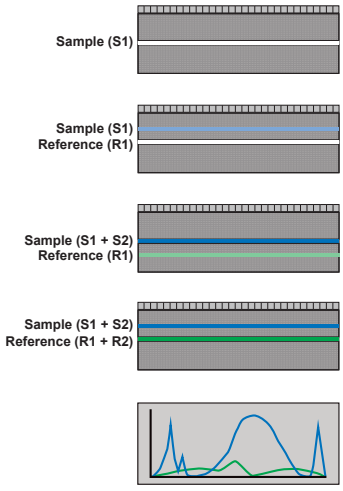
InGaAs SWIR FPA

Cameras with an InGaAs focal plane array (FPA) are also available. InGaAs is a III-V compound semiconductor that provides excellent photosensitivity in the near-infrared, or NIR, and the shortwave-infrared, or SWIR, regions of the spectrum.

Princeton Instruments has the broadest range of detector technologies for VUV-to-SWIR imaging and spectroscopy.

Advanced New SeNsR™ Technology

Thanks to its unique bi-directional clocking ability, BLAZE offers a new SeNsR operating mode for low-light applications. With SeNsR, it is now possible to rapidly shift the charge (i.e., signal) on the CCD without reading out the data.

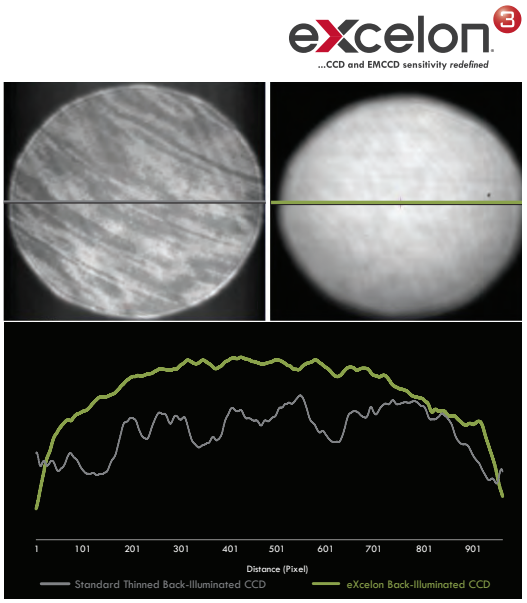


1. Using a fiber or mask, the center rows of pixels are exposed, leaving the rest of the CCD dark. Spectral data is collected for **Sample (S1),** which is then shifted up on the CCD and held in position without reading out the data.
2. A second exposure is then taken as **Reference (R1)** and then the Sample and Reference "signals" are shifted down on the CCD.
3. **Sample (S1)** is re-exposed and shifted up.
4. **Reference (R1)** is re-exposed and the process is repeated, alternating sample-reference exposures – **S1, R1, S2, R2, S3, R3, Sn, Rn, etc. –** until the desired accumulations are achieved.
5. Sample spectral data is accumulated as **S1+S2+S3+Sn** while reference data is accumulated as **R1+R2+R3+Rn.** Accumulated sample and reference data is then read out for processing.

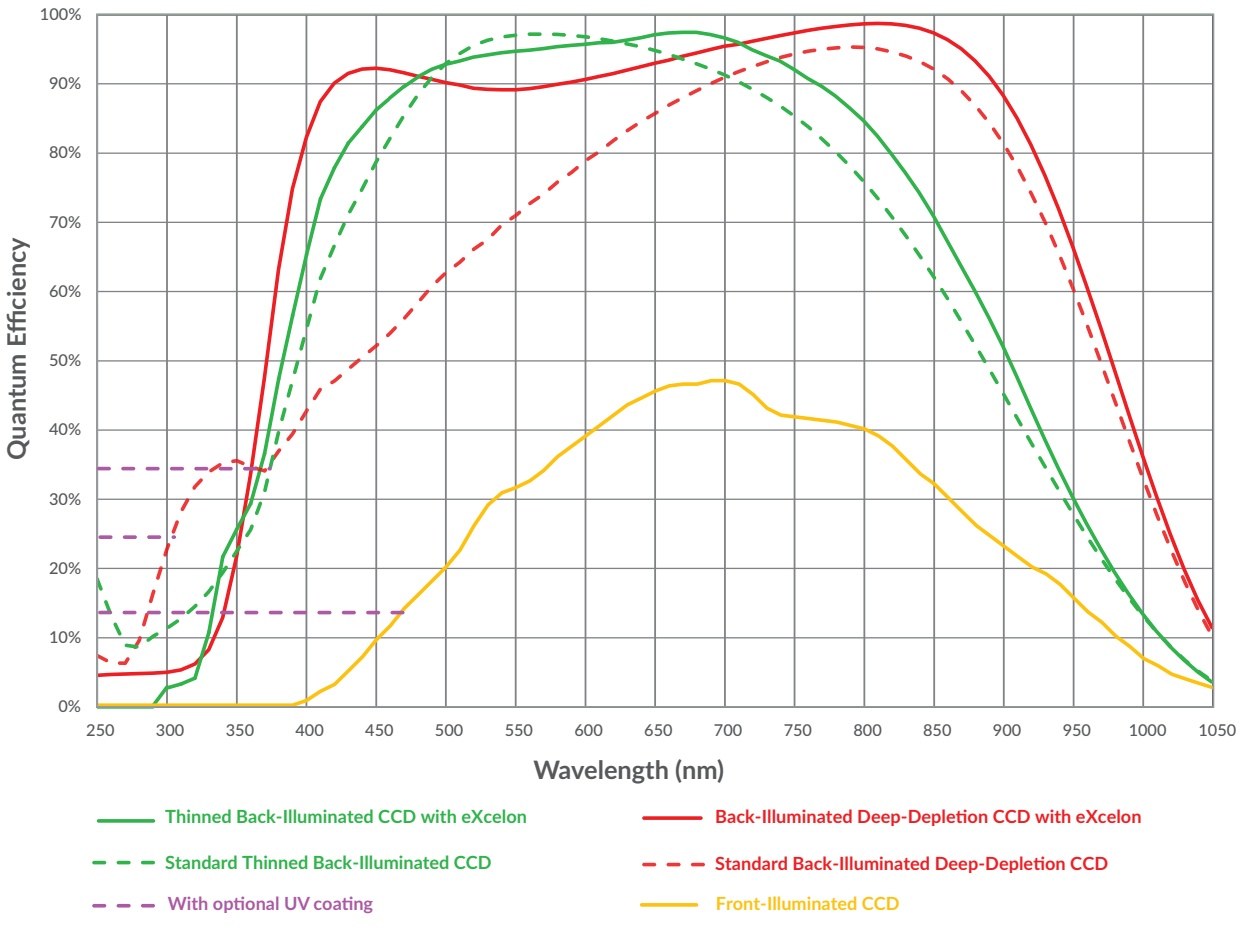
Patented eXcelon® Technology

Patented eXcelon technology for CCDs and EMCCDs, developed by Princeton Instruments and based on either standard thinned back-illuminated or standard back-illuminated deep-depletion architectures, provides two significant advantages:

- Higher sensitivity across broader wavelength range than standard thinned back-illuminated CCDs and standard back-illuminated deep-depletion CCDs
- Lower etaloning for eXcelon thinned back-illuminated CCDs (and etaloning almost eliminated for eXcelon back-illuminated deep-depletion CCDs)



Improvement in etaloning in eXcelon back-illuminated CCD cameras (right) over standard thinned back-illuminated CCD cameras (left).

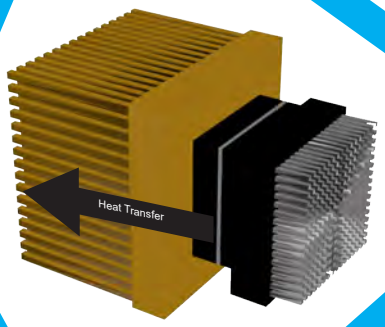


Proprietary ArcTec™ Cooling Technology

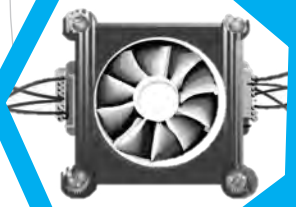
The most advanced thermoelectric cooling technology available for scientific-grade cameras, Princeton Instruments ArcTec uses custom-designed Peltier devices, advanced multi-stage thermoelectric cooling, and permanent all-metal UHV seals to achieve unprecedented, condensation-free **TRUE -100°C** sensor cooling without liquid nitrogen.

ArcTec design advantages:

- Ultra **efficient** heat exchanger



- Options are available that cool with **air only, liquid only** (for vibration-sensitive and thermally sensitive environments), or **both.**



+

- An all-metal, hermetically sealed vacuum design that is **guaranteed for life!**

NIRvana InGaAs cameras as well as SOPHIA and BLAZE large-format CCD cameras feature our advanced ArcTec cooling.

LightField® Software

Used in concert with our many award-winning imaging and spectroscopy instruments, Princeton Instruments LightField is the new benchmark for scientific software:

- Powerful 64-bit software package includes Microsoft® Windows® 10 support
- Built-in math engine for real-time data analysis
- Integrated LabVIEW® (National Instruments), MATLAB® (MathWorks), and Python® (PDF) automation support
- Supports Princeton Instruments IntelliCal® wavelength and intensity spectral calibration
- Synchronized view allows quick comparison to the same region or peak in two or more datasets
- Dependable data integrity via automatic saving to disk and retention of both raw and corrected data
- Works seamlessly in multi-user facilities by remembering each user's hardware and software configurations
- Exports to your favorite file formats, including FITS

Your Astronomy Ecosystem: Complete Integration

Built on decades of experience serving the astronomy community, Princeton Instruments has developed one of the most comprehensive software and hardware ecosystems.

Rest assured, whether it's a project involving a single camera or a complex system involving multiple telescopes/cameras/spectrographs, Princeton Instruments provides tools ready to speed up the work.

SPIE.

AAS AMERICAN ASTRONOMICAL SOCIETY

DISCOVERY

Our partnership with the astronomy community has enabled some amazing discoveries…

Camera Customization

Decades of technical expertise and application experience allow us to tailor the performance of our standard optical detection systems to meet your specific needs.

Figure 1 shows a 4” diameter all-sky multispectral imager by Keo Scientific Ltd. High sensitivity and correspondingly high low-light-level spatial resolution — less than a kilometer at 100 km altitude — are achieved by using a fast f/1.2 optical system by Keo Scientific and a customized version of our PIXIS:2048B scientific-grade, back-illuminated CCD detector. The design incorporates a field flattening plano-convex lens in place of a standard flat window.

Figure 1. *Sentry 4” multispectral imager.*

We also offer customized coatings, mirrors, optical filters, and optical assemblies.

Princeton Instruments incorporates custom designs such as coatings and optics. A field flattener plano-concave lens is depicted in Figure 2.

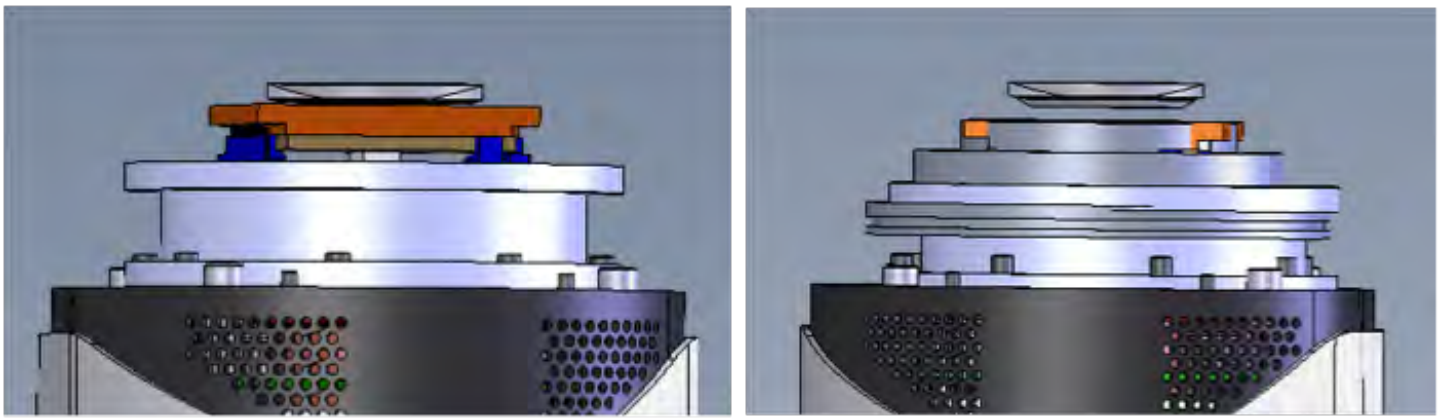


Figure 2.
Field flattener plano-concave lens.

Princeton Instruments has supplied hundreds of cameras to leading astronomical facilities around the world. Here's just a snapshot of some of the applications for which they are used!

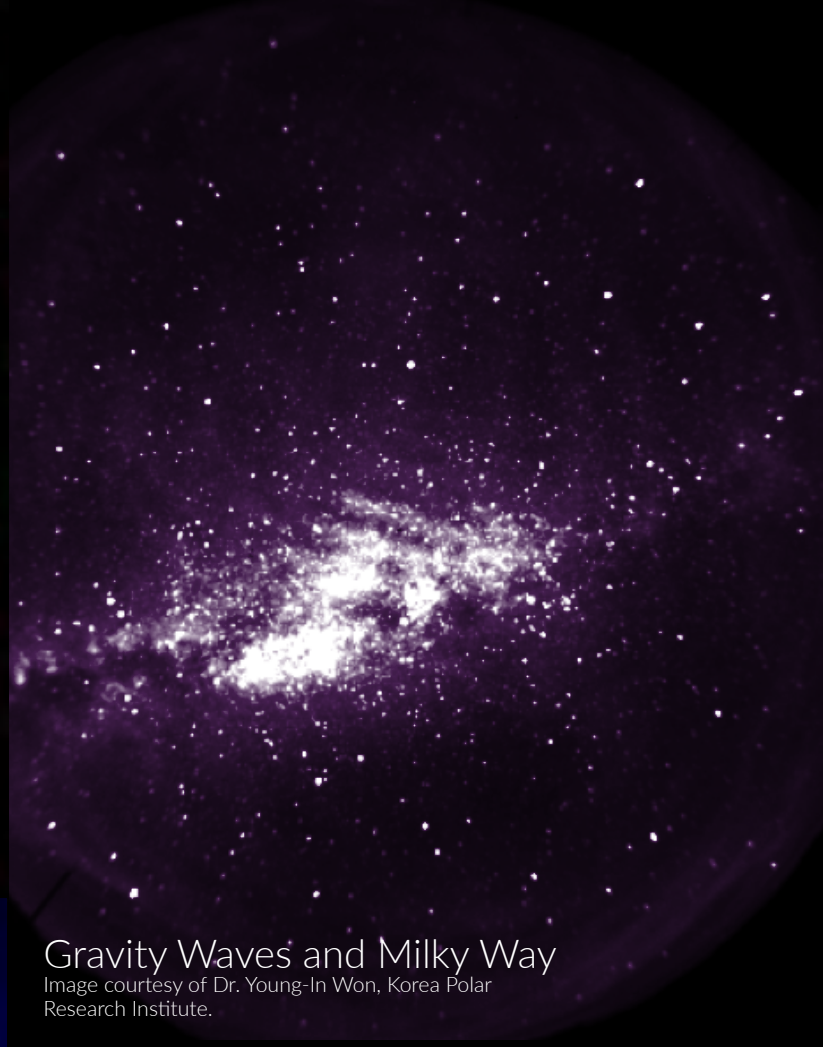
Fabry-Perot Interferometer Image
Taken using a back-illuminated 1k x 1k EMCCD camera from Princeton Instruments. Courtesy of Qian Wu, National Center for Atmospheric Research (Boulder, Colorado).

M51 Whirlpool Galaxy
Image courtesy of Rozhen National Astronomical Observatory, Bulgaria.

DF Tau Power Spectrum
Accumulated on 2000 speckle interferograms using a back-illuminated EMCCD camera from Princeton Instruments. Courtesy of Pleiades Publishing, Ltd.

Pluto and Charon

Acquired using a PIXIS camera with a back-illuminated 2k x 2k CCD. Courtesy of Prof. Elliott Horch, Southern Connecticut State University, New Haven.

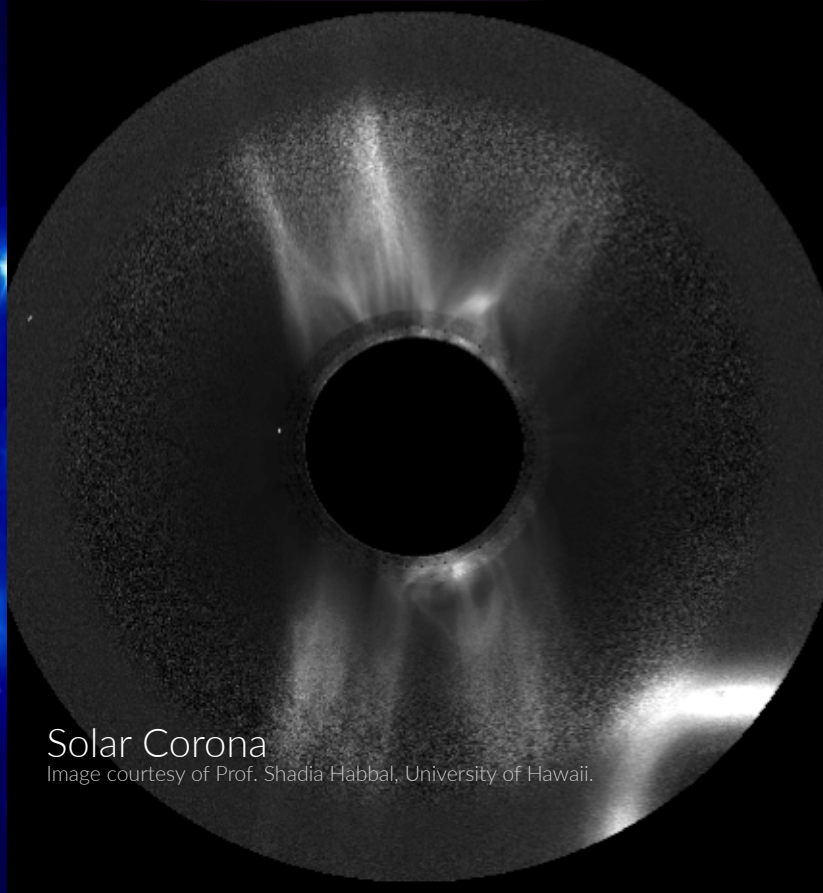


Gravity Waves and Milky Way

Image courtesy of Dr. Young-In Won, Korea Polar Research Institute.

Pleiades

Image courtesy of Rozhen National Astronomical Observatory, Bulgaria.

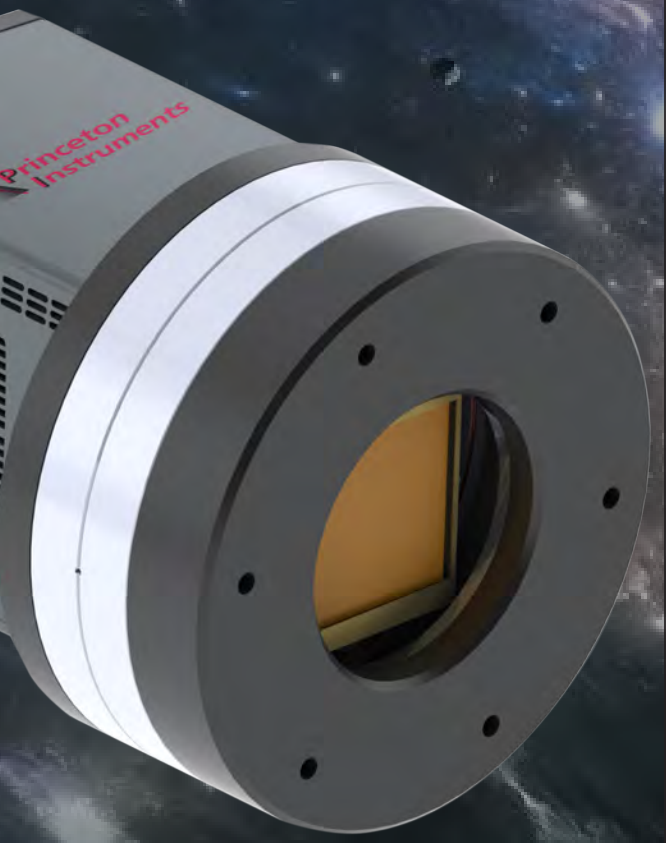


Solar Corona

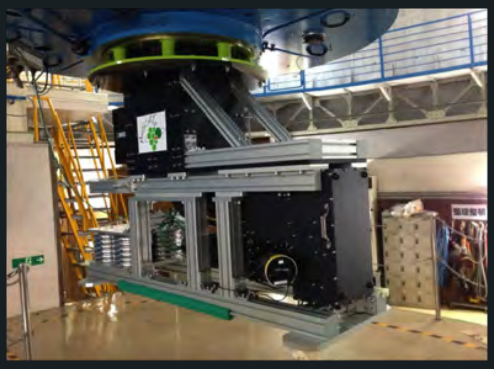
Image courtesy of Prof. Shadia Habbal, University of Hawaii.

SOPHIA®

The Most Advanced Line of Ultra-Low-Noise Scientific CCD Cameras for Astronomy

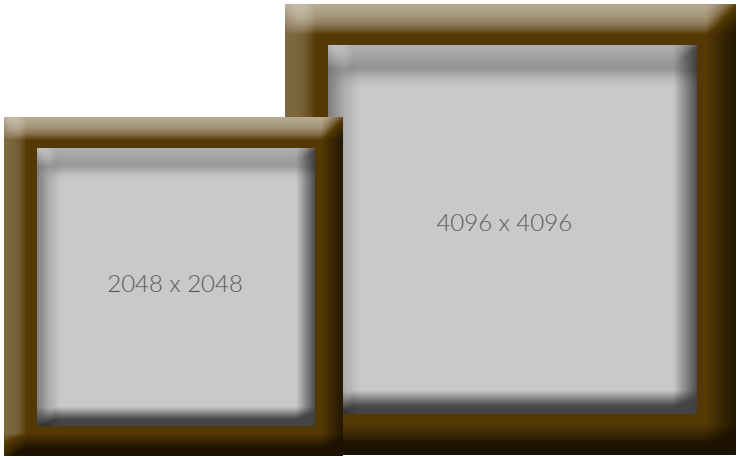


- 2k x 2k, 4k x 4k, and larger format back-illuminated CCDs
- eXcelon: patented technology for low fringing and enhanced sensitivity over broad wavelength range
- Proprietary ArcTec: deep thermoelectric cooling technology specially designed to cool large sensors down to -100°C
- Ultra-low-noise electronics design and flexible readout architecture allow detection of faint signals with or without pixel binning
- Fast 3 fps readout @ 2k x 2k for high-speed photometry
- 95% peak quantum efficiency, extended QE from UV to NIR
- All-metal hermetic vacuum seals to last a lifetime



MuSCAT (multicolor simultaneous camera) for studying atmospheres of transiting exoplanets installed on the 188 cm telescope at Okayama Astrophysical Observatory in Japan.

A Princeton Instruments CCD camera installed on the 1.0 meter telescope at Weihai Observatory of Shandong University, China.

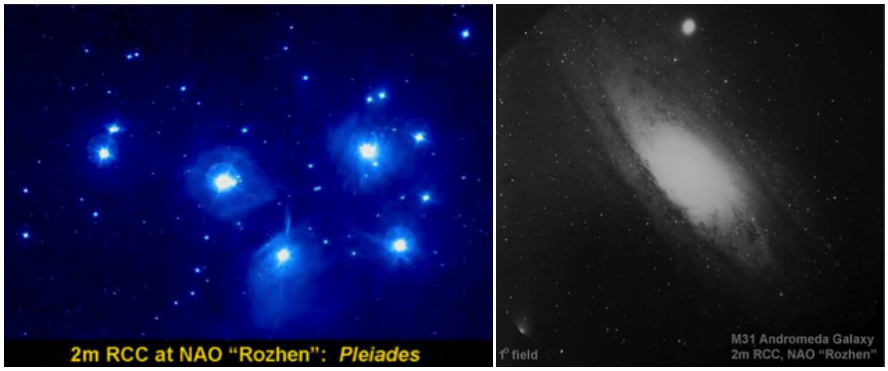


2048BX 4096BX

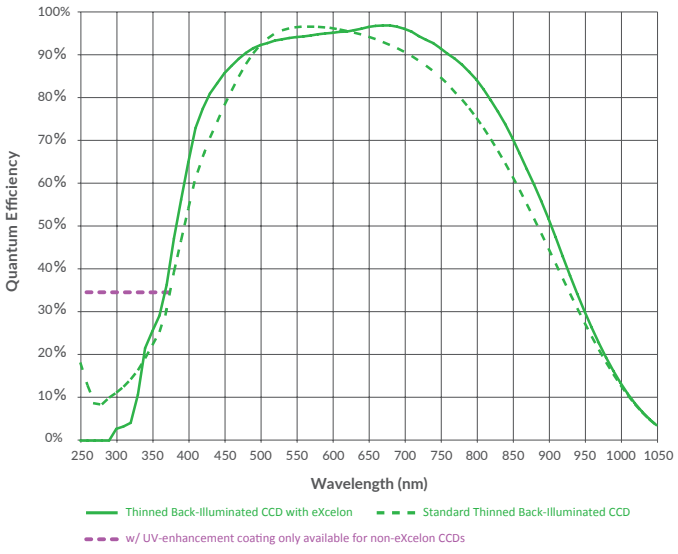
SOPHIA cameras deliver an unprecedented combination of sensitivity, speed, and flexibility!

Applications

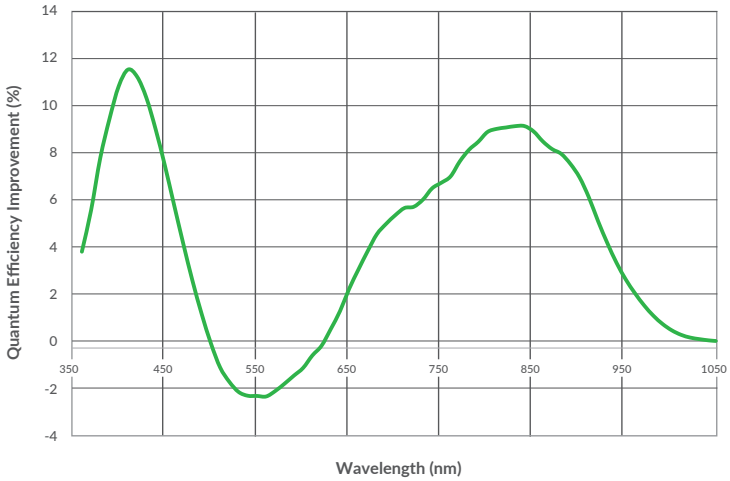
- Precision photometry
- High-temporal-resolution imaging
- Deep sky survey
- Astrometry
- Exoplanet detection
- Near-earth objects



Images courtesy of Rozhen National Astronomical Observatory, Bulgaria.



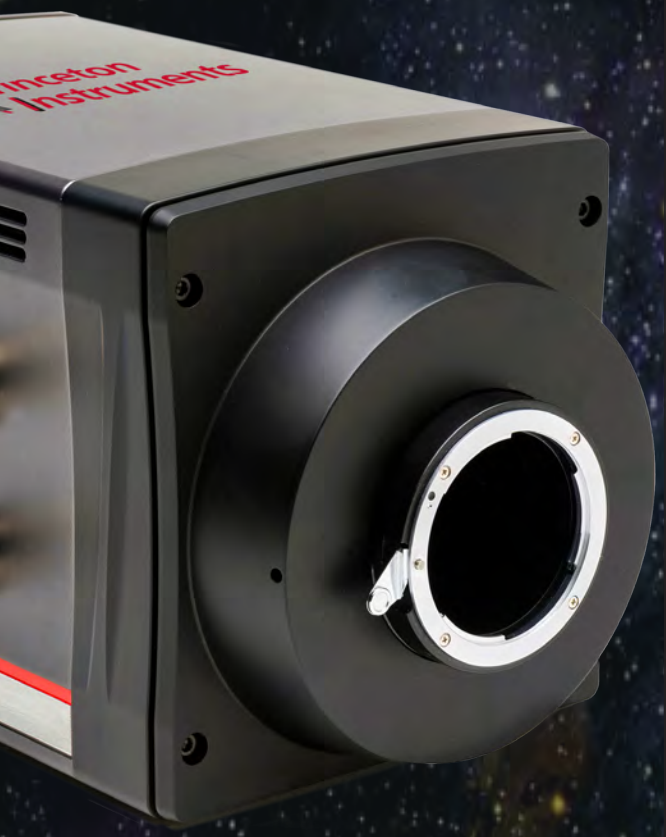
Typical QE of eXcelon back-illuminated CCDs and standard thinned back-illuminated CCDs. Purple dotted line on the left represents enhanced QE in UV region with optional UV-enhancement coating.



The improvement in QE provided by eXcelon back-illuminated CCDs relative to standard thinned back-illuminated CCDs.

BLAZE™

Next-Generation CCD Cameras for Spectroscopy and Imaging



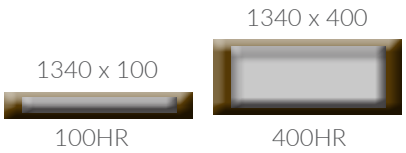
- 1340x100 and 1340x400 formats available for highest NIR sensitivity with new proprietary sensors
- Up to 75% QE @ 1000 nm for best sensitivity in near-infrared range. BLAZE HR: super-depleted, high-resistivity sensors.
- ≤2 e-/pixel/sec for low dark current below sky background. BLAZE BR-LD: inverted-mode, deep-depletion sensors.
- **TRUE -100°C** (using 20°C liquid assist) and -95°C using air (no chillers or cryocoolers) with no fear of condensation. Exclusive ArcTec technology thermoelectrically cools the CCD.
- ADC rates up to 16 MHz x 2 with discrete dual amplifiers for low-noise and high-speed operation

BLAZE camera and IsoPlane 320 spectrometer used to observe 8-21-17 solar eclipse from Willamette University (Salem, Oregon). Photo courtesy of Ronald Dantowitz, Clay Center Observatory Director, Dexter Southfield School (Brookline, Massachusetts).

SUPER SENSITIVE
Up to 75% QE @ 1000 nm

BLAZING FAST
Dual 16 MHz Readouts

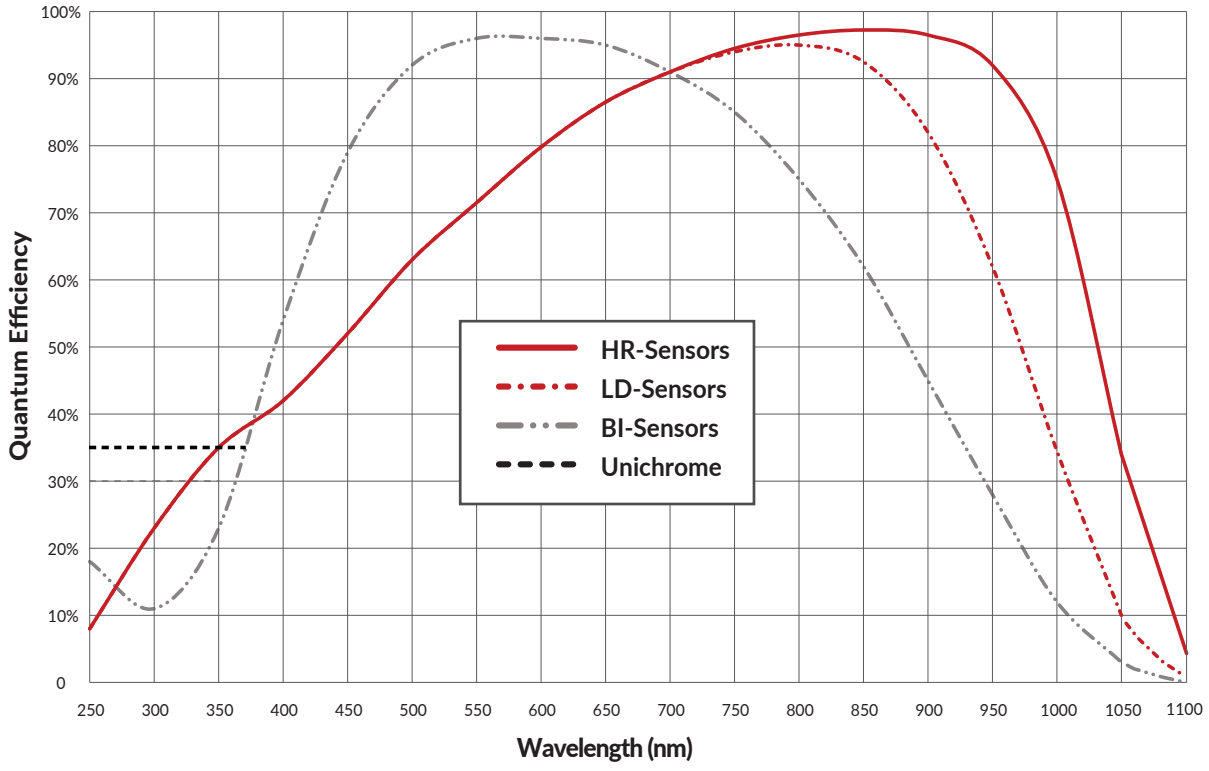
DEEPEST COOLING
TRUE -100°C



Applications

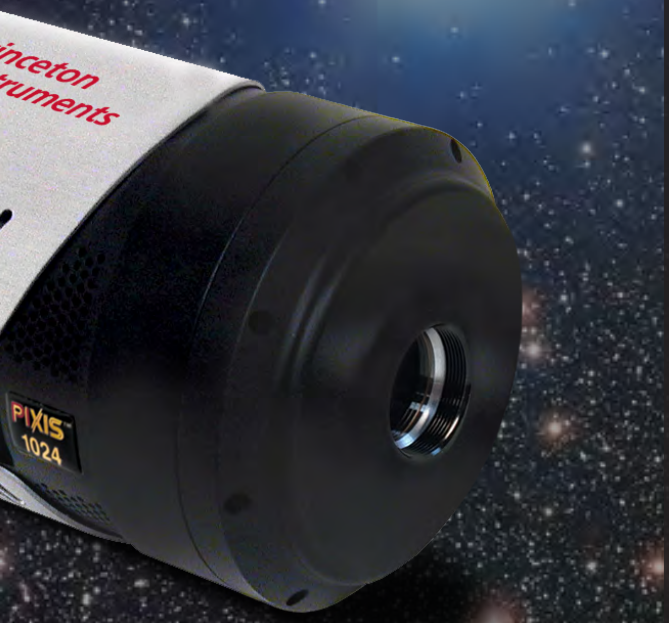
- Near-infrared photometry (r, i, z, and Y bands)
- Solar observations
- Near-infrared spectroscopy

BLAZE cameras deliver the highest NIR quantum efficiency, -100°C thermoelectric cooling, and low/no etaloning for spectroscopic observations that are out of this world!

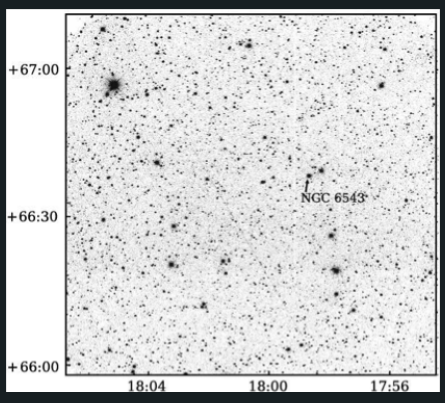


PIXIS

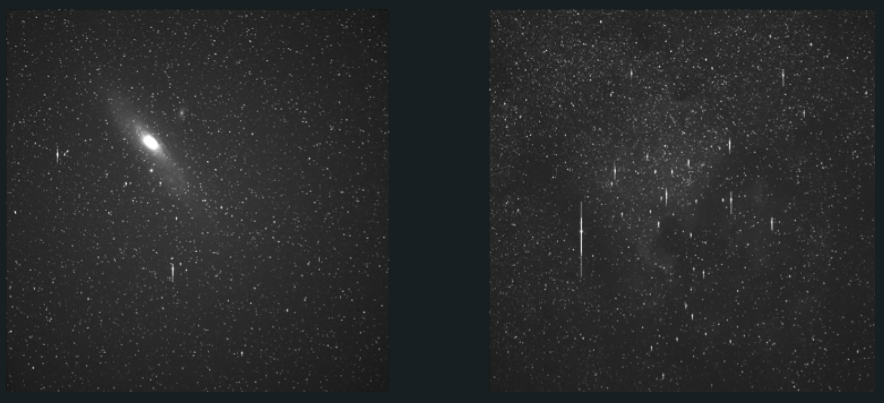
High-Quantum-Efficiency, Low-Noise Scientific CCD Cameras for Astronomy



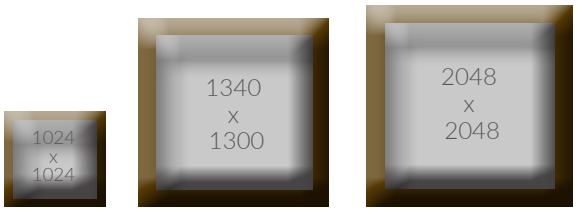
- 120 nm to 1100 nm enhanced sensitivity with patented eXcelon technology for low fringing
- >95% peak QE back-illuminated CCDs with up to 2k x 2k pixel array
- -70°C air/water cooling with proprietary XP technology
- USB 2.0 high-speed data interface
- Dual-amplifier design: high-sensitivity readout with reduced read noise for weak signals
- All-metal hermetic vacuum seals with lifetime vacuum guarantee



CCD observation in a filter of the Vilnius seven-color photometric system obtained with the Maksutov-type 35/51 cm telescope at the Molėtai Observatory in Lithuania. The planetary nebula NGC 6543 (Cat's Eye Nebula) is indicated. Image reprinted from Astronomy & Astrophysics, volume 544, article A49 (2012).



Images of the Andromeda galaxy taken with a PIXIS camera. Courtesy of Dr. Brian Oetiker, Sam Houston State University (Huntsville, Texas).

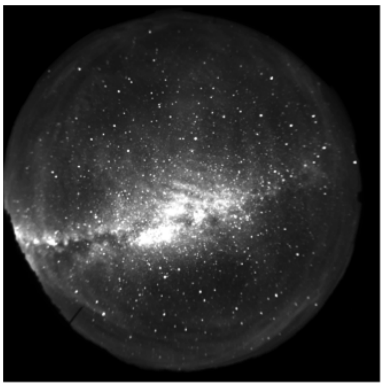


1024BX 1300BX 2048BX

PIXIS cameras offer eXcelon technology for back-illuminated deep-depletion CCDs, further improving both NIR sensitivity and etaloning performance when compared to standard back-illuminated deep-depletion CCDs!

Applications

- Precision photometry
- Deep sky survey
- Astrometry
- Exoplanets
- Near-earth objects



Gravity waves and Milky Way observed using a PIXIS camera with an all-sky field-of-view module. Image courtesy of Dr. Young-In Won, Korea Polar Research Institute.

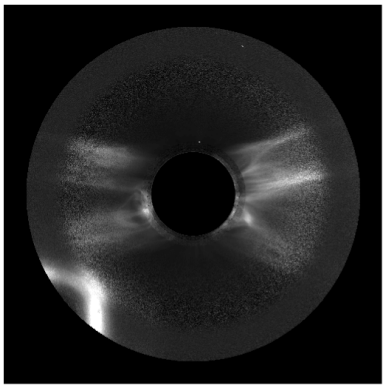
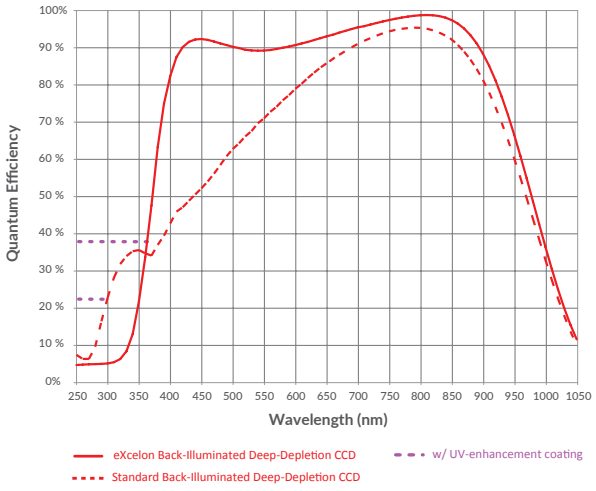
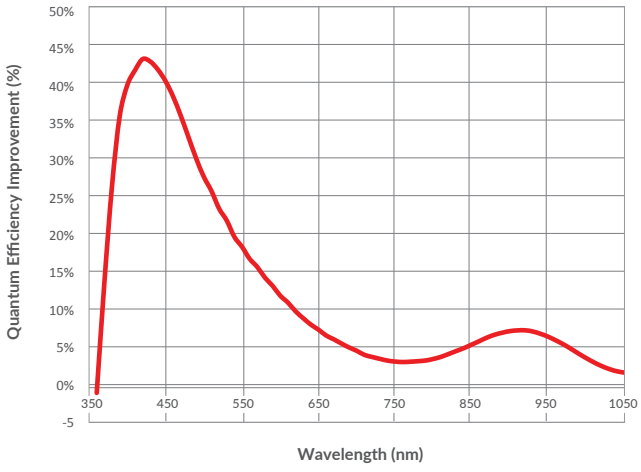


Image of solar corona taken with a PIXIS camera. Courtesy of Prof. Shadia Habbal, University of Hawaii.



Typical QE of eXcelon back-illuminated deep-depletion CCDs and standard back-illuminated deep-depletion CCDs.



The improvement in QE provided by eXcelon back-illuminated deep-depletion CCDs relative to standard back-illuminated deep-depletion CCDs.

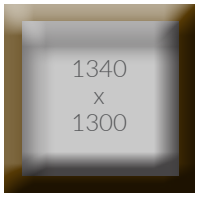
PyLoN®

The Only Cryogenically Cooled Scientific CCD Cameras for Astronomy

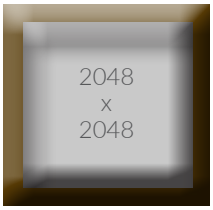
- Up to 2048 x 2048 pixel array (with 13.5 μm^2 pitch)
- -120°C (cryogenically cooled) ultra-low dark current back-illuminated CCDs
- >24 hours of liquid nitrogen hold time
- >1,000 frames/sec at 4 MHz readout speed for highest spectral rate
- Dual-amplifier readout design for reduced read noise and increased effective dynamic range
- eXcelon: patented technology for low fringing and enhanced sensitivity over broad wavelength range
- GigE industry-standard, fast-transfer data interface

A cryogenically cooled Princeton Instruments CCD camera installed on the 80 cm reflector at Xinglong Observatory in China.

A cryogenically cooled Princeton Instruments CCD camera installed on the 2.16 meter reflector at Xinglong Observatory, NAOC.



1300BX



2048BX

PyLoN cameras utilize digital correlated double sampling and bias stabilization to provide the best read noise performance below 1 MHz readout speed, improved linearity, and a constant baseline for multiple-exposure, long-integration-time applications!

Applications

- Precision photometry
- Steady-state imaging
- Deep sky survey
- Astrometry
- Exoplanets
- Near-earth objects

Image courtesy of Rozhen National Astronomical Observatory, Bulgaria.

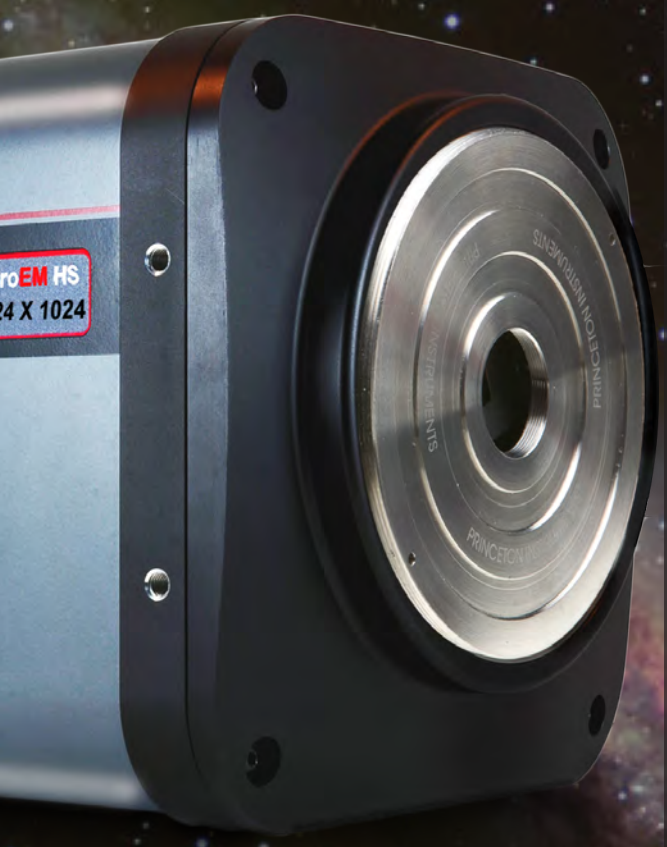
Cryogenically Cooled eXcelon Sensors

This unique Princeton Instruments technology features:

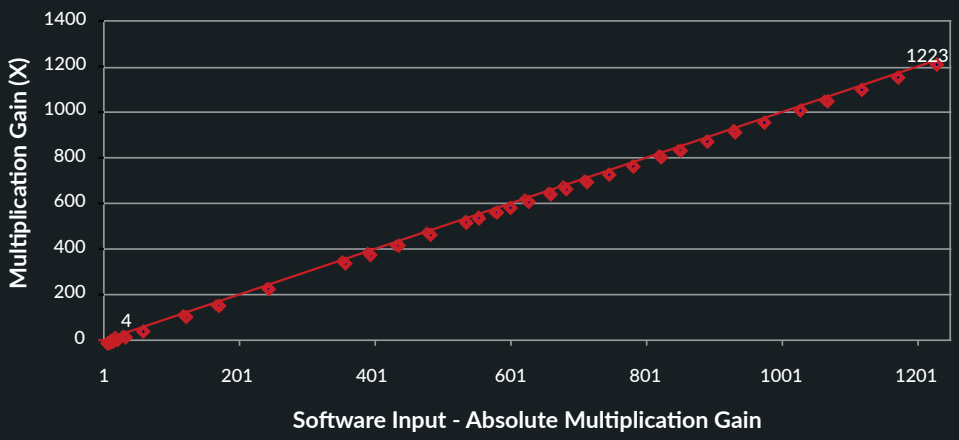
- Dark current on the order of 1 e-/p/hr for exposure times of minutes to hours
- A single input window for maximum sensitivity
- Refill requirement of only once per day
- Setup flexibility with optional end-on and all-directional dewars

ProEM®-HS

The Fastest EMCCD Cameras for High-Speed Applications



- 30 fps at full resolution, supports ROI/binning for ultra-fast frame rates
- eXcelon3: patented technology for low fringing and enhanced sensitivity over broad wavelength range
- OptiCAL electron-multiplying gain calibration: repeatable precision for lifetime of camera
- Base Active Stability Engine (BASE) for stable baseline reference
- All-metal hermetic vacuum seals (lifetime vacuum guarantee)
- GigE industry-standard, fast-transfer data interface



After OptiCAL, a high-precision EM gain calibration method that allows EM gain to be controlled in linear, absolute steps.

512BX3

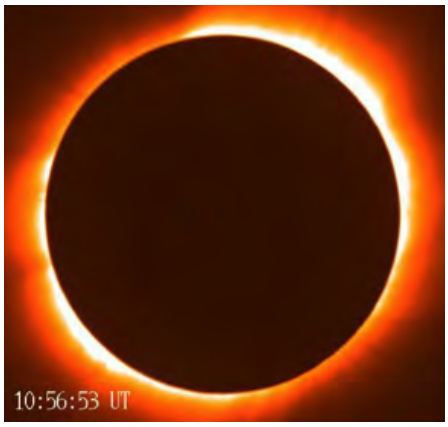
1KBX3-10µm

1024BX3

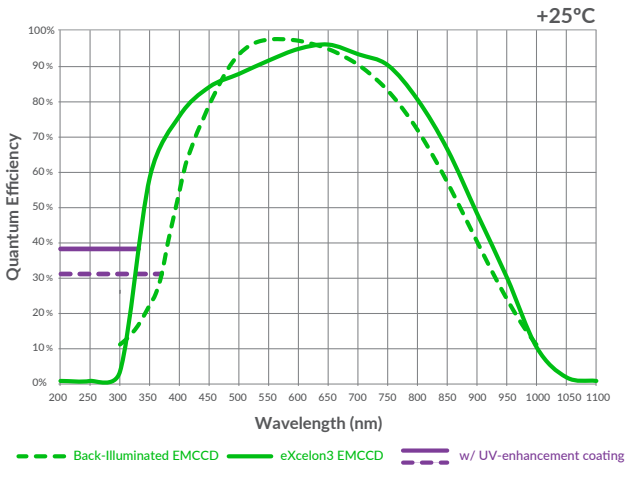
Princeton Instruments recommends EMCCD cameras that utilize patented eXcelon3 technology.

Applications

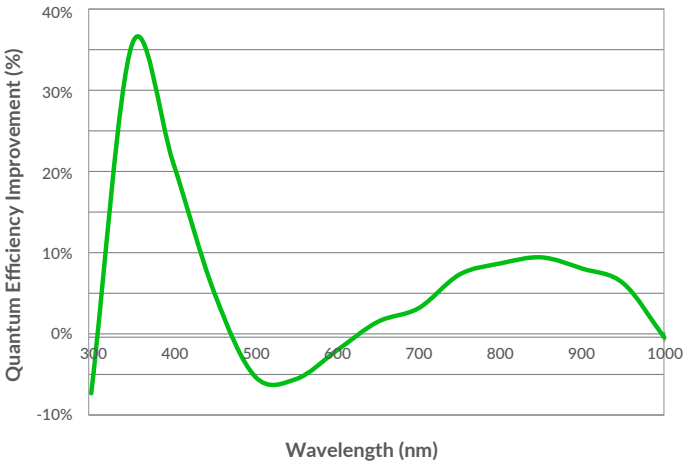
- Adaptive optics
- Lucky imaging
- Speckle imaging
- Exoplanets
- Gamma ray bursts
- Wave front sensors
- Precision photometry



Images of a solar eclipse taken with a ProEM camera at the Aryabhatta Research Institute of Observational Sciences (Nainital, India).



Typical QE of eXcelon3 back-illuminated EMCCDs and standard thinned back-illuminated EMCCDs. Solid/dashed purple lines on the left represent enhanced QE in UV region with optional UV-enhancement coatings.

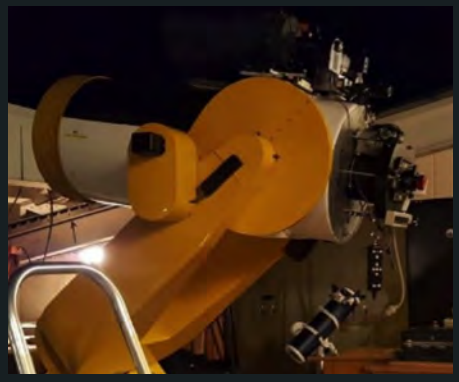


The improvement in QE provided by eXcelon3 back-illuminated EMCCDs relative to standard thinned back-illuminated EMCCDs.

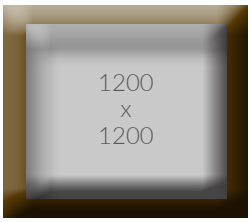
KURO™

The First Back-Illuminated sCMOS Cameras for Ultra-Fast Astronomy Applications

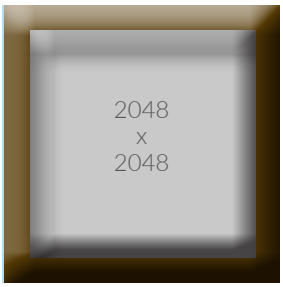
- >95% peak QE back-illuminated sCMOS sensors
- Up to 4 MP resolution, 11 μm^2 pixel pitch
- 100% light-sensitive pixel area (fill factor), no microlenses
- 82 fps @ 2k x 2k, more than 3,000 fps at reduced resolution
- 12-bit and 16-bit readout
- Extended UV and NIR sensitivity
- USB 3.0 data interface (high bandwidth)
- 1.3 e- rms (low readout noise) to detect weak signals
- Thermoelectric cooling (air/water)



Photos of KURO camera courtesy of Eliot Young, Southwest Research Institute (Boulder, Colorado).



1200B

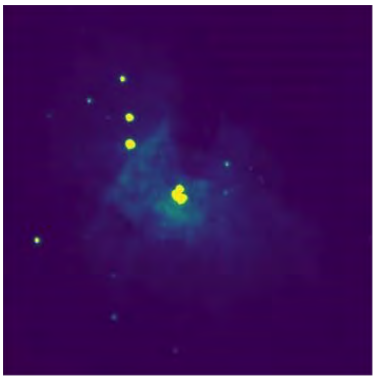


2048B

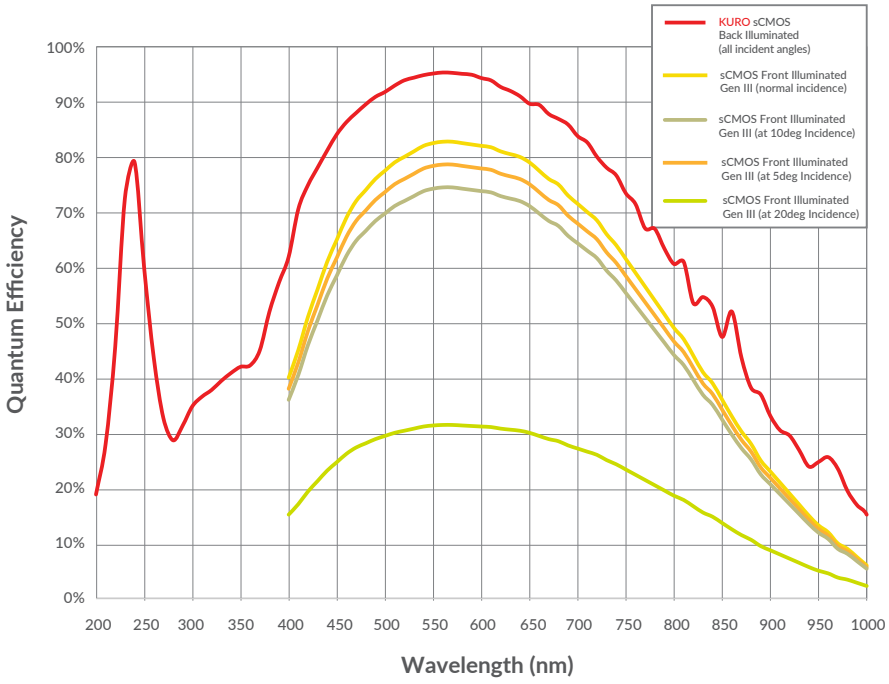
These new, back-illuminated sCMOS sensors provide CCD-like quantum efficiency (>95%) and dynamic range while preserving the impressive frame rates of previous-generation, front-illuminated sCMOS cameras!

Applications

- Adaptive optics
- Lucky imaging
- Speckle imaging
- Exoplanets
- Near-earth objects
- Solar astronomy



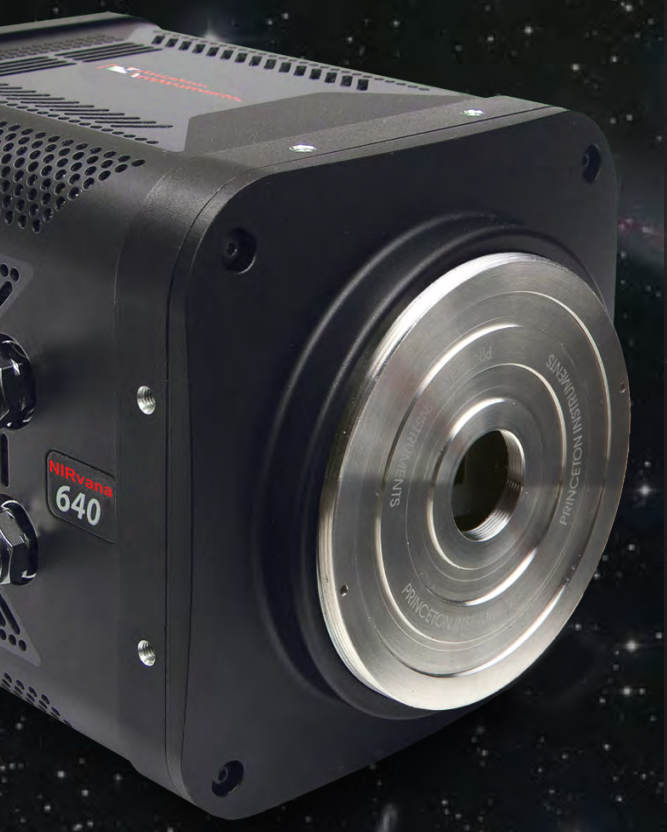
Images captured with a KURO back-illuminated sCMOS camera. Star cluster (left), Orion Nebula. Courtesy of Southwest Research Institute (Boulder, Colorado).



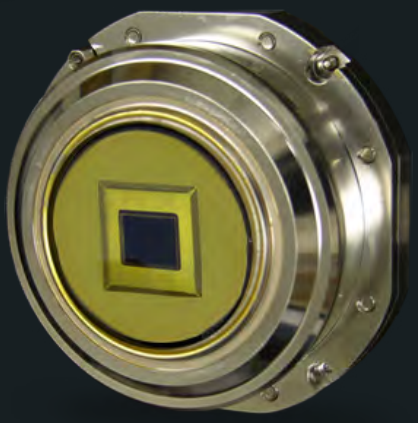
Back-illuminated sCMOS technology provides higher QE than front-illuminated sCMOS sensors across a broad spectral range, including the UV. Unlike front-illuminated sCMOS sensors, which claim ~80% peak QE by relying on microlenses that reduce fill factor (and significantly degrade quantum efficiency when light is incident at any angle other than normal to the sensor surface), back-illuminated sCMOS sensors deliver >95% peak QE without microlenses or their associated compromises.

NIRvana®

The Only Scientific-Grade InGaAs Cameras on the Market for Quantitative Near-Infrared (NIR) / Shortwave-Infrared (SWIR) Imaging and Spectroscopy Applications



- -85°C (thermoelectrically cooled) for long integration time and low dark noise
- 640 x 512 high-speed InGaAs FPA (with 20 μm^2 pixel pitch)
- Fast 110 fps @ 10 MHz (full-frame readout)
- 0.9 µm to 1.7 µm response (>80% typical QE from 1.0 µm to 1.6 µm)
- All-metal hermetic vacuum seals (lifetime vacuum guarantee)
- GigE industry-standard, fast-transfer data interface
- 16-bit digitization and low read noise for outstanding dynamic range



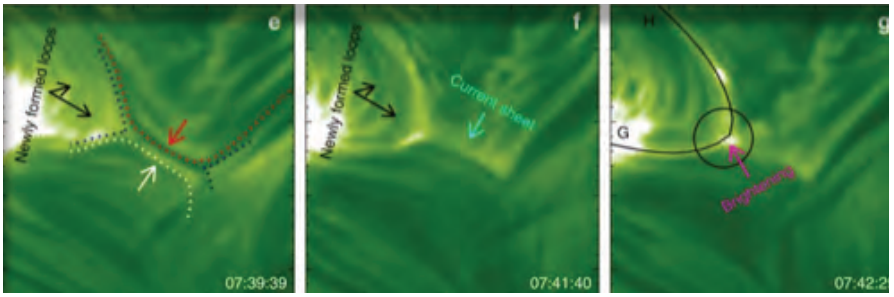
Thermoelectrically cooled NIRvana cameras use a single optical window with double-sided antireflective coating to provide the highest photon throughput, >98% transmission, in the NIR / SWIR band.

640 / 640ST

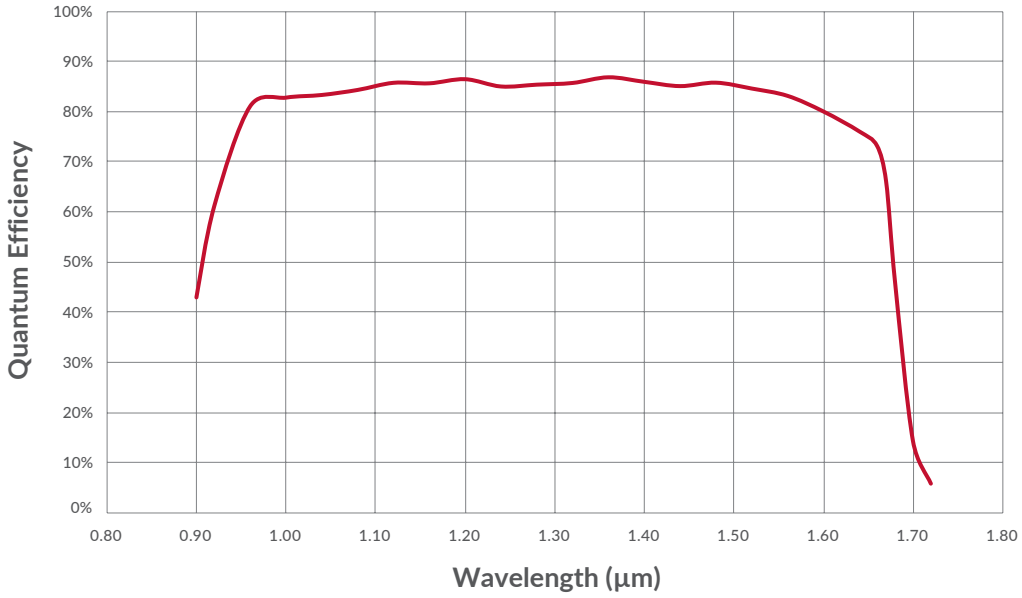
Princeton Instruments utilizes unique vacuum technology and advanced thermoelectric cooling to chill the high-speed, high-QE InGaAs sensor of the NIRvana down to -85°C and achieve the lowest possible dark noise.

Applications

- High-frame-rate imaging in NIR / SWIR
- Time-resolved coronal observations in NIR / SWIR
- J and H band applications
- Exoplanet transit surveys
- Photometric measurements of M-types and brown dwarfs
- Low-elevation observatories



The first evidence of fast reconnection in a solar filament eruption was found via the New Vacuum Solar Telescope and a NIRvana camera (Yunnan Astronomical Observatory, China).



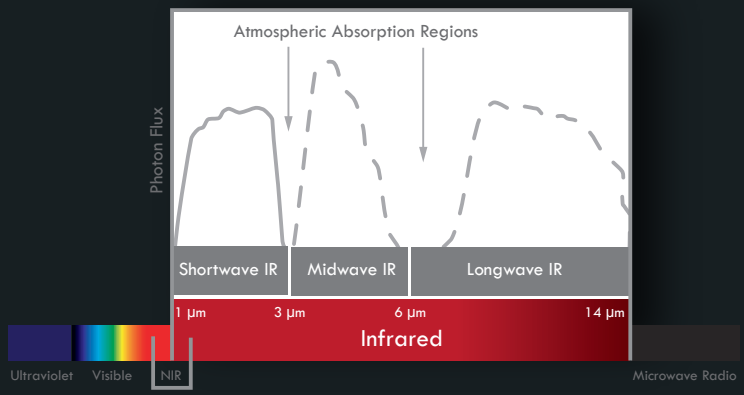
The quantum efficiency of a standard InGaAs FPA thermoelectrically cooled to -85°C.

NIRvana® LN

Scientific Camera Cryogenically Cooled to 83 K (-190°C) for NIR / SWIR Imaging

- 0.9 µm to 1.6 µm response (70% typical QE from 1.3 µm to 1.6 µm)
- >30 hours of liquid nitrogen hold time
- >60 minute integration time with ultra-low dark noise
- Integrated cold shield limits the effects of ambient thermal background
- 640 x 512 low-read-noise InGaAs FPA (with 20 μm^2 pixel pitch)
- ~3 fps at full resolution
- GigE industry-standard, fast-transfer data interface
- Supports nondestructive readout (NDRO) mode

InGaAs delivers superb photosensitivity in the NIR and SWIR regions of the spectrum.

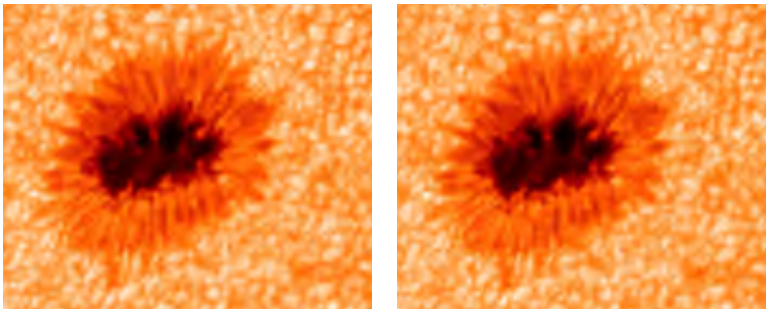


640LN

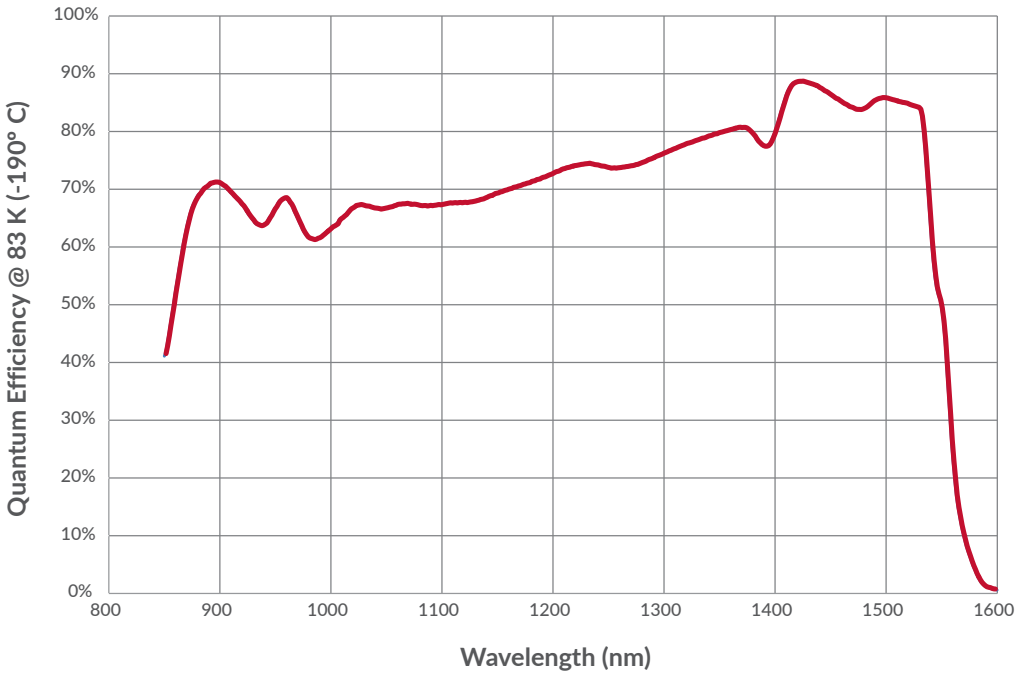
The InGaAs sensor of the NIRvana LN is cooled via liquid nitrogen down to 83 K (-190°C) in order to improve signal-to-noise ratio for the most demanding NIR / SWIR applications. The camera's 16-bit digitization and low-read-noise sensor provide outstanding dynamic range.

Applications

- Steady-state imaging
- Long-integration coronal observations



Images of sunspots (1565.3 nm channel) taken using a NIRvana camera at the Yunnan Astronomical Observatory in China.



The quantum efficiency of a standard InGaAs FPA cryogenically cooled to -190°C.

Camera Specifications

	SOPHIA CCD		PIXIS CCD			PyLoN CCD		BLAZE CCD			
											
	2048BX	4096BX	1024BX/ BRX	1300BX	2048BX	1300BX	2048BX	100HR	100LD	400HR	400LD
Sensor type	Back-Illuminated CCD with eXcelon							Exclusive Back-Illuminated High-Resistivity Silicon			
Resolution (pixels)	2048 x 2048	4096 x 4096	1024 x 1024	1340 x 1300	2048 x 2048	1340 x 1300	2048 x 2048	1340 x 100		1340 x 400	
Pixel pitch (µm)	15 x 15		13 x 13	20 x 20	13.5 x 13.5	13.5 x 13.5	20 x 20	20 x 20		20 x 20	
Sensor cooling	-90ºC		-70ºC	-60ºC		-110ºC		-95ºC / -100ºC			
Typical dark charge	0.00025 e-/p/s		0.0004 e-/p/s (BX), 0.02 e-/p/s (BRX)	0.001 e-/p/s	0.005 e-/p/s	0.000083 e-/p/s	0.00001 e-/p/s	0.0015 e-/p/s	0.0005 e-/p/s	0.0015 e-/p/s	0.0005 e-/p/s
Max full frame rate	3 fps	<1 fps	1.7 fps	1.07 fps	0.44 fps	2.04 fps	0.92 fps	218 fps	140 fps	54 fps	35 fps
Max read-out speed	16 MHz (4 MHz/port)		2 MHz			4 MHz		16 MHz	10 MHz	16 MHz	10 MHz

Camera selection guide

Dynamic range	Yes	Yes	Yes	Yes
Sensitivity	Yes	Yes	Yes	Yes
Speed	Very Good	Good	Good	Very Good
UV-VIS-NIR-SWIR	UV-VIS-NIR	UV-VIS-NIR	UV-VIS-NIR	UV-VIS-NIR
Computer interface	USB 3.0	USB 2.0	GigE	USB 3.0

	ProEM-HS EMCCD			KURO BI-sCMOS		NIRvana InGaAs		
								
	512BX3	1KBX3_10µm	1024BX3	1200B	2048B	640	640ST	640LN
Sensor type	Back-Illuminated EMCCD with eXcelon3			Back-Illuminated sCMOS		InGaAs		
Resolution (pixels)	512 x 512	1024 x 1024	1024 x 1024	1200 x 1200	2048 x 2048	640 x 512		640 x 512
Pixel pitch (µm)	16 x 16	10 x 10	13 x 13	11 x 11		20 x 20		20 x 20
Sensor cooling	-90ºC	-70ºC	-65ºC	-25ºC		-85ºC	-65ºC	-190ºC
Typical dark charge	0.001 e-/p/s	0.002 e-/p/s	0.002 e-/p/s	0.7 e-/p/s		300 e-/p/s	1500 e-/p/s	10 e-/p/s
Max full frame rate	61 fps	30 fps	25 fps	82 fps (12 bits)	41 fps (12 bits)	110 fps		2.77 fps
Max read-out speed	20 MHz	36.67 MHz	30 MHz			10 MHz		250 kHz

Camera selection guide

Dynamic range	Yes	No	No	Yes		Yes		
Sensitivity	Yes			Yes		Yes		
Speed	Excellent			Excellent		Excellent		Good
UV-VIS-NIR-SWIR	UV-VIS-NIR			UV-VIS		NIR-SWIR		
Computer interface	GigE			USB 3.0		GigE		

IsoPlane® Spectrometers

Best-in-Class, Astigmatism-Free Imaging Spectrometers Set New Standards of Performance and Versatility

- Patented, astigmatism-free design
- High resolution across the entire focal plane
- ±0.01 nm* high wavelength accuracy with IntelliCal
- ±0.0015 nm* high wavelength repeatability with IntelliCal
- Extremely high stray-light rejection
- Fixed-position camera mount with micrometer focus adjustment

** IsoPlane 320 with 1200 groove/mm grating @ 435 nm*

PIXIS camera and IsoPlane 320 spectrometer used for spectroscopic detection of space debris test at SHAO 60 cm telescope. Photo courtesy of Prof. Zhenghong Tang, Shanghai Astronomical Observatory, Chinese Academy of Sciences.

BLAZE camera and IsoPlane 320 spectrometer used to observe 8-21-17 solar eclipse from Willamette University (Salem, Oregon). Photo courtesy of Ronald Dantowitz, Clay Center Observatory Director, Dexter Southfield School (Brookline, Massachusetts).

Additional Photo Credits

Page 4 (left to right)

Giant Magellan Telescope. Courtesy of GMTO.

Okayama Astrophysical Observatory. Courtesy of NAOJ.

Royal Observatory Greenwich. Courtesy of Royal Museums Greenwich.

Fuxian Solar Observatory. Courtesy of Yunnan Observatories, CAS.

Cerro Tololo Inter-American Observatory. Courtesy of NOAO.

Page 5 (left to right)

Haleakala Observatory 1.6 Meter Telescope. Courtesy of AMOS.

Xinglong Observatory 2.16 Meter Telescope. Courtesy of NAOC.

Okayama Astrophysical Observatory 188 cm Telescope. Courtesy of NAOJ.

Okayama Astrophysical Observatory 188 cm Telescope. Courtesy of NAOJ.

Rozhen National Astronomical Observatory 2 Meter RCC Telescope. Courtesy of Rozhen NAO.

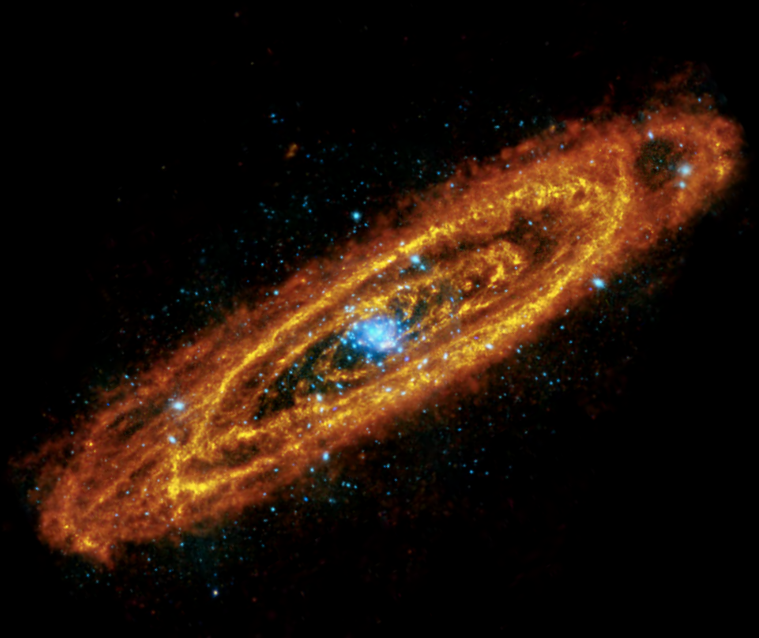
Page 20

Background image: ESO / F. Comeron

Pages 18, 22, 24, 26, 28, 30, 34

Background images: ESO

CONTACT YOUR LOCAL PRINCETON INSTRUMENTS REPRESENTATIVE FOR ADDITIONAL INFORMATION.



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