

- FBP: Broad Spectrum Optical Fiber
- Solarization Resistant

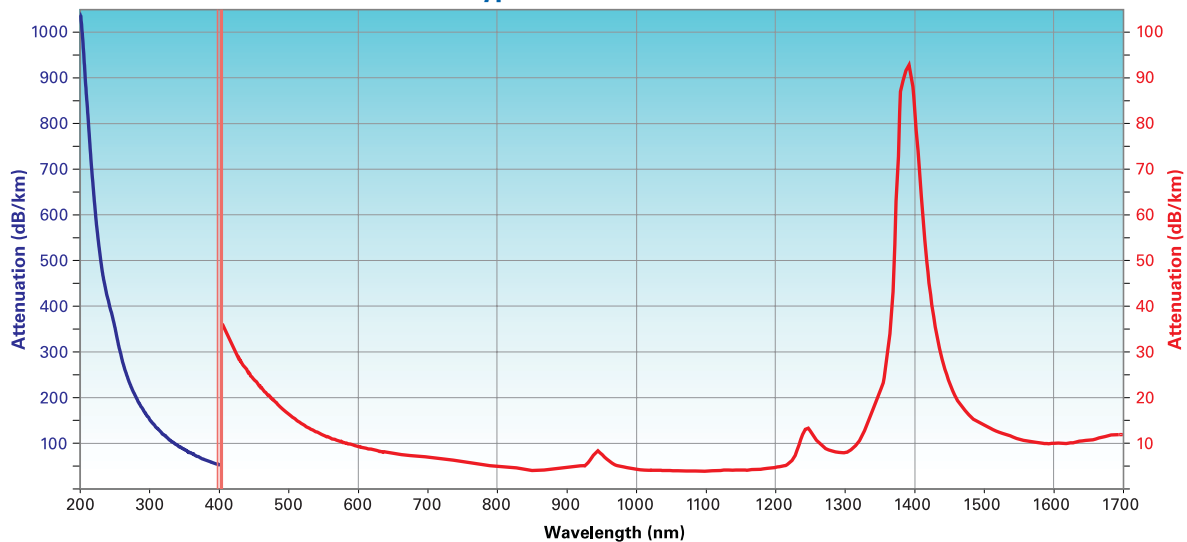
Characteristics

- New Lower Loss Broad Spectrum Fiber, 275-2100nm
- Excellent Focal Ratio Degradation Characteristics
- Step Index
- Numerical Aperture: 0.22 ± 0.02
- Silica Core, Doped Silica Clad
- Cost Effective
- Polyimide Concentricity $\pm 3\mu\text{m}$
- Tight Tolerance
- Operating Temperature: -65°C to $+300^\circ\text{C}$
- Proof Tested to 100kpsi
- Custom Sizes, Buffers, Jackets, Assemblies Available

This fiber is designed to operate over a very broad range of wavelengths. It is produced with a Patent Pending process that allows more flexibility to meet smaller quantity requests for a variety of core:clad ratios.

Product Descriptor	Core (μm)	Clad (μm)	Buffer (μm)
FBP200220240	200 \pm 4	220 \pm 4	239 \pm 5
FBP300330370	300 \pm 6	330 \pm 7	370 \pm 10
FBP400440480	400 \pm 8	440 \pm 9	480 \pm 7
FBP500550590	500 \pm 10	550 \pm 10	590 \pm 10
FBP600660710	600 \pm 10	660 \pm 10	710 \pm 10
FBP100120140	100 \pm 3	120 \pm 3	140 \pm 4
FBP200240280	200 \pm 4	240 \pm 4	275 \pm 5
FBP320385415	320 \pm 8	385 \pm 8	415 \pm 10
FBP050070085	50 \pm 2	70 \pm 2	90 \pm 3
FBP100140170	100 \pm 3	140 \pm 3	170 \pm 5

Typical Attenuation



QUALITY MANAGEMENT SYSTEM
 CERTIFIED BY DNV
ISO 9001:2000

18019 N. 25th Avenue • Phoenix, AZ 85023-1200
 Voice: (602) 375-4100 Fax: (602) 375-4110
 E-Mail: sales@polymicro.com
 URL: <http://www.polymicro.com>

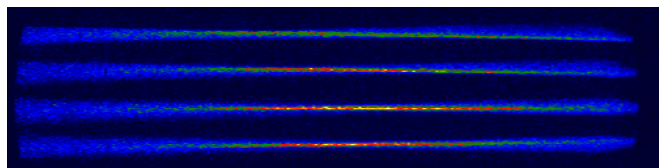
- Flexible Capillary
- Multimode Optical Fiber
- Specialty Assemblies
- Micro-Components

GENERAL FEATURES

VERSATILITY - Used in air the spectral range of these instruments extends from 185-nm to 78- μ m, and with vacuum down to 105-nm (depends on the grating.) For intermediate ranges a purge gas can be used (Nitrogen, for example.) McPherson's SNAP IN gratings allow the alignment-free use of many different gratings. Easily view a wider spectral range or obtain higher resolution! You can retrofit years later and not have to worry about alignment with the McPherson SNAP IN approach. Our dual grating turret also accept these gratings.

McPherson optics are Aluminum coated with a top layer of Magnesium Fluoride. This coating provides extremely good response in a broad spectral range. If required by your application other coatings (Gold, Silver, Aluminum, etc.) can be provided.

Well equipped, these instruments feature: multiple entrance and exit ports, high precision wavelength drives, extended range operation, Echelle, and oversize grating mounting capabilities. Optional features include grating turrets, imaging optics, multi-source, and multi-



detector turrets further increasing versatility.

IMAGING SPECTROGRAPH - These instruments can be equipped with imaging optics. Adapters for all popular CCD and photodiode array detectors (even those for the Infrared) can be supplied. Larger focusing optics fully illuminate a 50-mm wide focal plane. (In some cases we can even supply photographic adapters!)

SPECTRAL SOFTWARE - McPherson executable LabView™ software provides a simple user interface for instrument control. All spectrometer functions supported by device controllers, etc. can be automated. A selection of choice signal recovery devices from EGG,

BETTER THROUGHPUT and WIDER RANGE -

McPherson Czerny-Turner instruments with focal lengths greater than 0.67-meters allow you to use larger 120-mm x 140-mm grating or a 110-mm x 110-mm grating. The large grating offers almost 40% more area, achieving a faster f/number, and more throughput. In these models the grating can also rotate through an auxiliary 20° for extension of wavelength range. For the 1200-g/mm grating the high wavelength changes from 1300-nm to 1575-nm (more than 20% extra wavelength coverage!)

HIGH PERFORMANCE DRIVE - All instruments use a digital scanning motor directly coupled to a mechanical lead screw wavelength drive. The mechanical screw and sine arm enable manual positioning and generate the sinusoidal motion required for linear wavelength readout when scanning a spectrometer. The mechanical sub-step is more expensive to produce than the direct worm drive design and it insures stability and repeatability. In addition this approach allows users to manually set up experiments and tune without computer support.

REDUCED STRAY LIGHT - In the UV-VIS and near IR wavelength range, our excellent stray light characteristics can be further improved by installing the McPherson Model 608 Prism Predisperser. The predisperser may also be used as a spectral order sorter when Echelle gratings are installed. The Model 608 can be retrofit to instruments already in the field.

BILATERAL SLITS - All instruments come with bilateral slits that are continuously adjustable by precision micrometer from 5 to 4000- μ m. Micrometer readout is in 10-micron thimble divisions. Interpolation may allow reading and setting of smaller intervals. Slit height can be varied by a stepped aperture from 2 to 20-mm. To meet your configuration requirement monochromator slits may be positioned at the axial (end) or lateral (side) ports of the monochromator. Optional stepper motorized slit micrometers can be provided. Also, optional curved slits can be provided for coma correction – even at extreme slit heights.

ACCESSORIES - McPherson supplies a full line of accessories including sources and detectors for use with air path and vacuum instruments. Equipped these instruments with multi-fiber imaging systems, sample



SPECIAL FEATURES

- **Highest Throughput Commercial Instrument**
 - Patented "Snap-In" gratings
 - Large focal plane
 - Imaging Optics
 - Multiple slit locations
 - Rugged Construction
- Extended wavelength range setting
 - Double Pass optics (option)
 - Echelle gratings(option)
 - Prism predisperser (option)

DETAIL SPECIFICATION AND GRATING SELECTION

Focal Length	0.67-meter, Czerny Turner design Spectrometer with Patented "Snap-In" gratings
Slit Locations	Axial and lateral with optional extra entrance and exit port selection mirrors
f No.	4.7 (5.8 with smaller grating)
Grating Size	120 x 140-mm (or 110 x 110-mm) - Echelle gratings up to 220-mm wide
Accuracy	0.05 nm (with 1200-g/mm grating)
Reproducibility	±0.005 nm (with 1200-g/mm grating)
Focal Plane	50-mm maximum width, multiply dispersion by the width of your detector for range
Wavelength Range	refer to grating of interest for range, in extended position increase top limit 20%

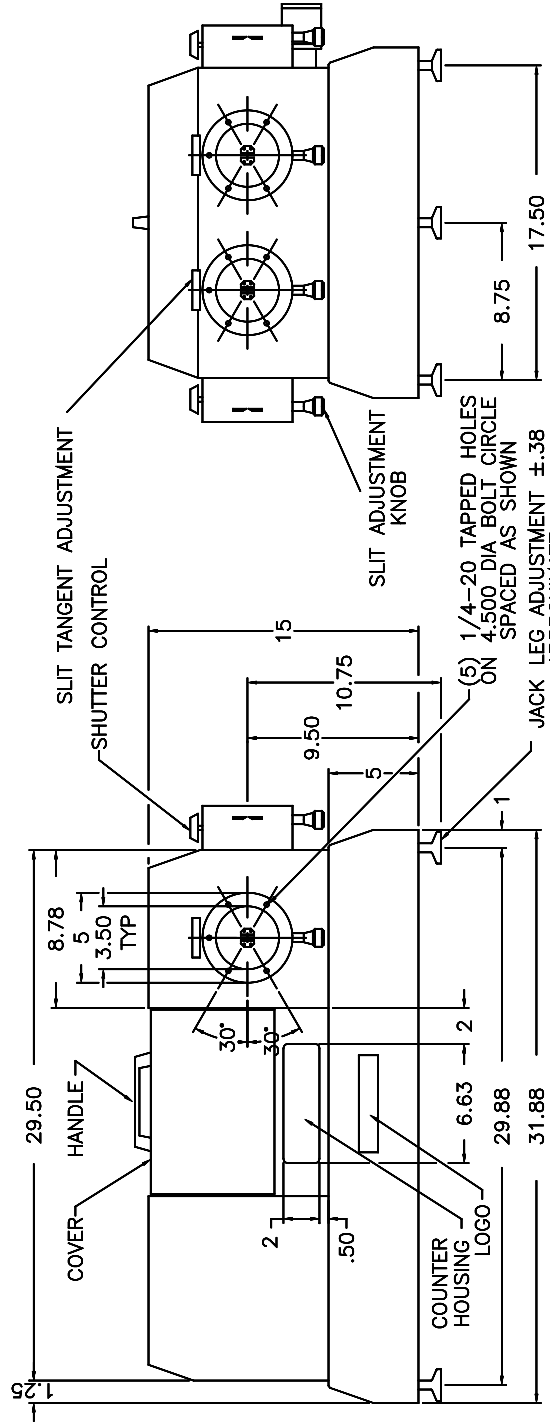
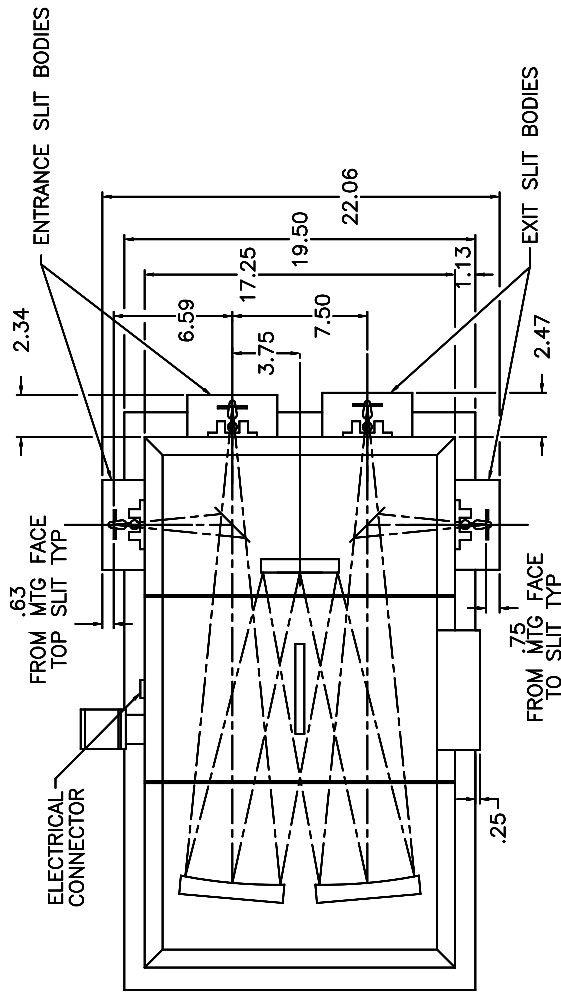
Grating Groove Density (g/mm)	3600	2400	1800	1200	600	300	150	75
Resolution** (nm)	0.012	0.018	0.02	0.03	0.06	0.12	0.24	0.48
Dispersion (nm/mm)	0.43	0.62	0.83	1.24	2.48	4.96	9.92	19.84
Wavelength Range	185 - 430 nm	185 - 650 nm	185 - 860 nm	185 - 1300 nm	185 - 2600 nm	185 nm - 5.2 um	185 nm - 10.4 um	185 nm - 20.8 um
Available Grating Blazes	Holographic* 240	Holographic* 240 300	Holographic* 400 500	Holographic* 250 300 500 750 1 um	Holographic* 300 500 750 1 um 1.85 um	300 500 750 1 um 3 um 4 um	300 500 750 1.25 um 2.5 um 4 um 6 um 8 um	2 um 3 um 8 um 10 um 12 um

** Spectral resolution typically measured at 313.1 nm

All specifications are for single pass operation.

spec.sht/pm1075/207

**0.67-meter focal length, f/4.7
High Throughput Spectrometer
McPherson Model 207**



NOTE: HOUSING TAPPED 3/8-16 UNC APPROXIMATELY .75 DEEP, 3 PLACES



ProEM: 512B

The ProEM: 512B camera from Princeton Instruments is the most advanced EMCCD camera available on the market today, utilizing the latest low-noise read out electronics and a 512x512 back illuminated EMCCD to deliver single photon sensitivity. This true 2-in-1 camera features a high speed EM mode to capture fast kinetics and a low speed normal CCD mode with very low read noise for precision photometry applications. It provides advanced features such as solid baseline stability and linear EM gain control. The ProEM: 512B is cooled to below -80°C using either air or liquid, or a combination of both. Its all metal, hermetic vacuum seals are warranted for life - the only such guarantee in the industry.

The ProEM: 512B EMCCD camera also features, for the first time, the latest Gigabit Ethernet (GigE) interface that allows remote operation over a single cable without the need for custom framegrabbers.

FEATURES

BENEFITS

Electron multiplication (EM) gain	Low-noise, impact-ionization process for single-photon sensitivity
OptiCAL™	Linear, absolute EM gain calibration using built in precision light source EM and Non-EM modes for the lowest noise and the best linearity.
BASE™	Baseline Active Stability Engine - stable bias for quantitative measurements
PINS™	Princeton Instruments Noise Suppression technology. Independently optimized EM and non-EM modes for the lowest noise and the best linearity.
Back-illuminated CCD	>90% peak quantum efficiency for the highest available sensitivity
Frame-transfer architecture	Allows 100% duty cycle imaging for tracking applications
Deep cooling	Thermoelectric cooling below -80°C minimizes dark current and allows long exposure times Camera can be cooled with air or water, or a combination of both, and fan can be permanently turned off for vibration-sensitive environments
Single optical window	Vacuum window is the only optical surface between incident light and the CCD surface - No losses due to multiple optical surfaces
Built-in shutter	Conveniently capture dark reference frames and protect camera from dust when not in use
Dual amplifiers	Individually optimized signal chains for a true 2-in-1 camera configuration, for high speed (EM mode) or long integration (normal CCD mode) applications
16-bit digitization	Wide dynamic range to capture dim and bright signals in a single image
10- and 5-MHz readout	Video rates at full-frame resolution. Use ROI/binning for hundreds of frames per second
100-kHz readout	Noise performance of a slow scan camera for precise photometry applications
Kinetics readout mode	Powerful readout mode offers microsecond time resolution between sub-frames
Gigabit Ethernet (GigE)	Reliable data transmission over 50m for remote operation
Software interface	Universal interface for easy custom programming, real-time focus & image access via circular buffers
C-mount (Adjustable)	Easily attaches to microscopes, standard lenses, or other optical equipment

Applications:

Single molecule detection, spectroscopy, chemiluminescence, astronomy, adaptive optics, hyperspectral imaging, phosphor imaging and tomography

SPECIFICATIONS

Image sensor	e2v CCD97; back-illuminated, frame-transfer EMCCD	
CCD format	512 x 512 imaging pixels 16 x 16 μm pixels 8.2 x 8.2 mm imaging area (optically centered)	
	EM mode	Normal CCD mode
Read noise (typical)	25 e- rms @ 5 MHz 50 e- rms @ 10 MHz Read noise effectively reduced to <1 e- rms with on-chip multiplication gain enabled	3 e- rms @ 100 kHz 7 e- rms @ 1 MHz 12 e- rms @ 5 MHz
Full well (typical)	800 ke- (output node)	200 ke- (single pixel)
Non-Linearity	<2%	<1%
Analog gain (typical)	12, 6, 3 e-/ADU	3.2, 1.6, 0.8 e-/ADU
Deepest cooling temperature (@ +20°C ambient)	-80°C +/- 0.05°C (typical) -70°C +/- 0.05°C (guaranteed)	
Dark current @ -70°C	0.005 e-/p/sec (typical) 0.02 e-/p/sec (maximum)	
Clock induced charge (CIC) (typical)	0.005 e-/pixel/frame measured with 33msec exposure time and ~1000x multiplication gain	
Electron multiplication (EM) gain	1 to 1000x, controlled in linear, absolute steps	
Digitization	16 bits @ 10 MHz, 5 MHz, 1 MHz and 100kHz	
Vertical shift rate	300 nsec/row - 5 μsec /row (variable)	
Binning	Flexible binning in vertical and 2x to 32x in horizontal	
Operating systems supported	Windows XP/Vista	
I/O signals	Exposure, Readout, Trigger In	
Operating environment	0 to 30°C ambient, 0 to 80% relative humidity, non-condensing	

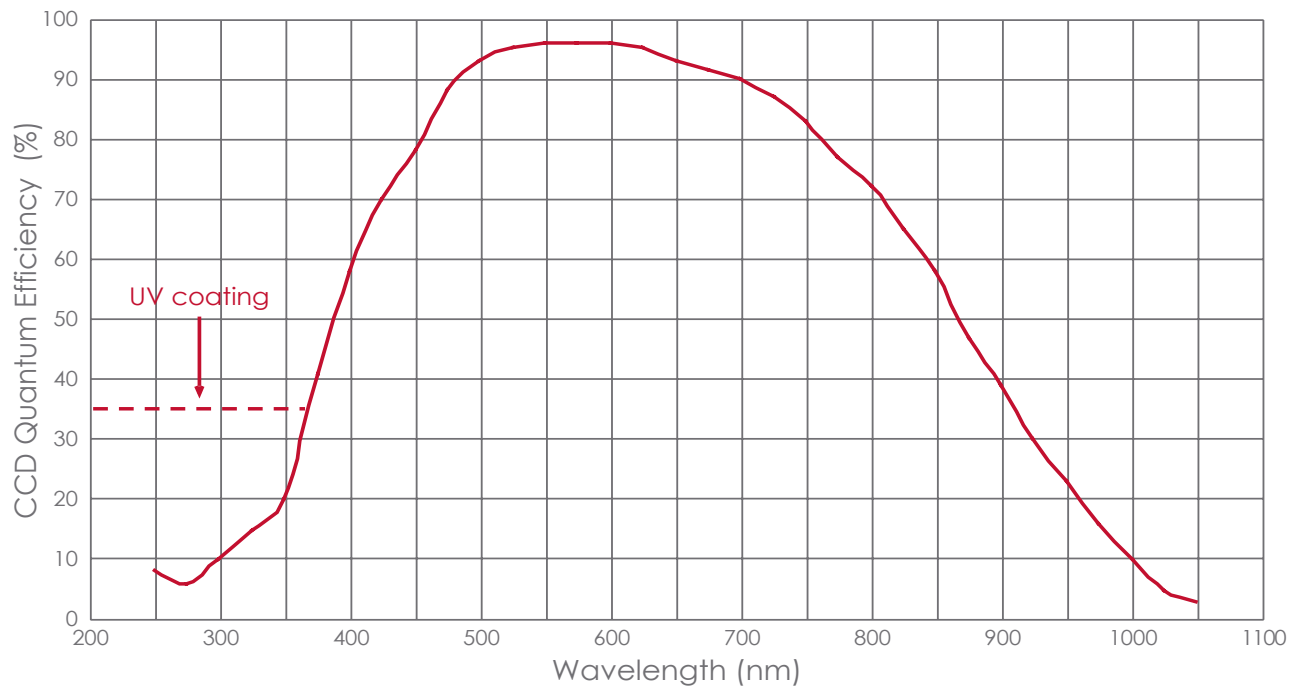
NOTE: All specifications subject to change

FRAME RATE (fps)

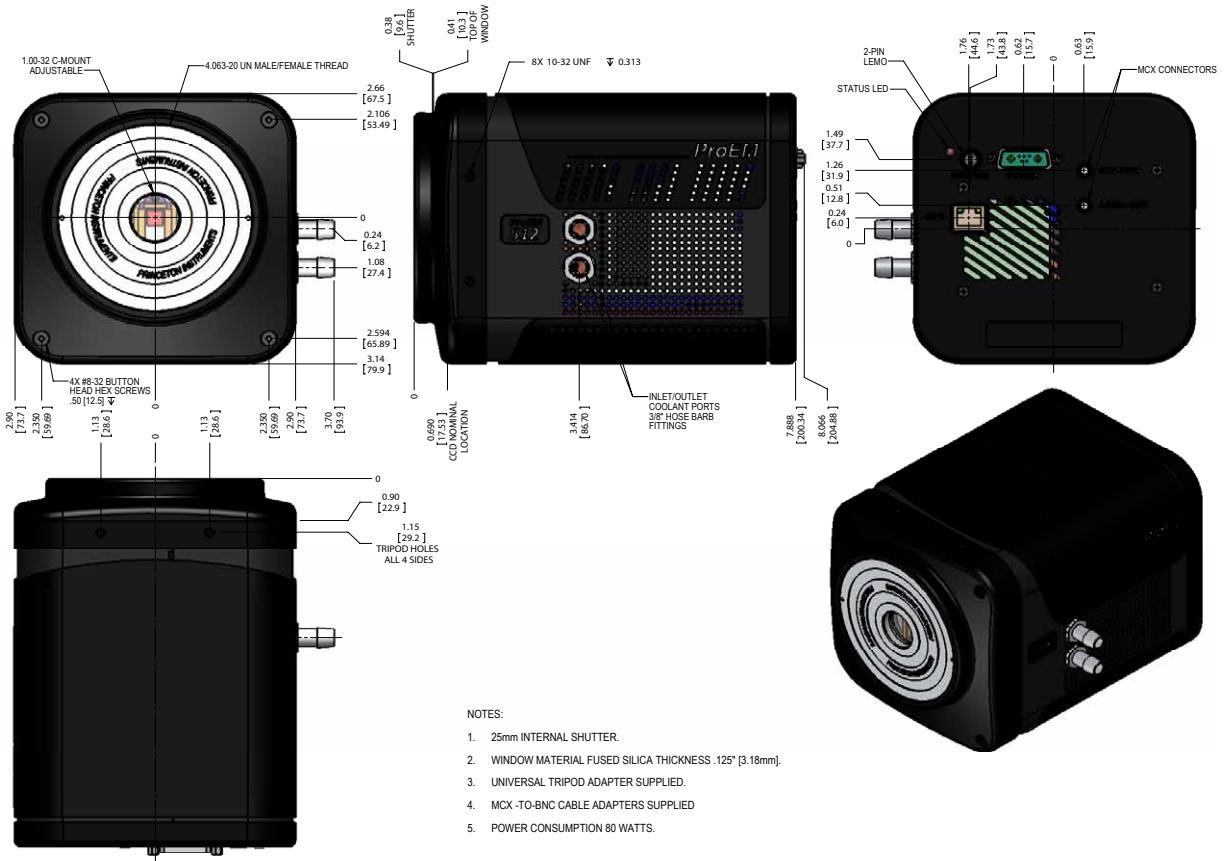
ROI/Bin	512 x 512	256 x 256	128 x 128	64 x 64	32 x 32
1 x 1	33	65	122	222	373
2 x 2	65	122	222	373	565
4 x 4	122	222	373	565	763
8 x 8	222	373	565	763	926

NOTE: Frame rate measured at 10 MHz digitization and 450 nsec/row vertical shift.
"Custom chip" mode increases frame rate at reduced ROI by 2x to 3x.

QUANTUM EFFICIENCY



OUTLINE DRAWING



NOTES:

1. 25mm INTERNAL SHUTTER.
2. WINDOW MATERIAL FUSED SILICA THICKNESS .125" (3.18mm).
3. UNIVERSAL TRIPOD ADAPTER SUPPLIED.
4. MCX -TO-BNC CABLE ADAPTERS SUPPLIED.
5. POWER CONSUMPTION 80 WATTS.

ProEM

Frequently Asked Questions

1. What is ProEM?

ProEM is the latest EMCCD camera platform from Princeton Instruments launched in January 2009. Currently two models -ProEM: 512B (512x512) and ProEM: 1024B (1kx1k) are available.

2. What are the salient features of ProEM?

ProEM is the highest performance EMCCD camera on the market. It features the most advanced low noise electronics, precise timing and ultra deep cooling required for challenging low light, high frame rate as well as steady state imaging and spectroscopy applications

- **XP vacuum technology:**
 - All metal, hermetic vacuum seals
 - No epoxies or o-ring seals used that degrade vacuum/cooling over time
 - Permanent vacuum guarantee
 - Metal-to-glass brazing is used to attach the vacuum window
 - Thousands of cameras in operation around the world
- **Advanced thermal design:**
 - TE cooling down to -80°C (-70°C guaranteed for life)
 - Cooling by air or liquid or both.
 - When using liquid cooling, turn off fan permanently to reduce vibration.
 - Thermostating precision of +/- 0.05°C
- **OptiCAL™**
 - Linearized, self-calibrated electron multiplication gain via built-in precision light source
 - User accessible for field calibration
- **PINS™ (Princeton Instruments Noise Suppression technology)**
 - Lowest read noise in both EM and Non-EM readout ports
 - EM Mode
 - ~25 e- rms @ 5MHz (best in the industry!)
 - ~50 e- rms @ 10MHz
 - Non-EM (Traditional) readout
 - ~3 e- rms @ 100 kHz (best in the industry!)
 - ~7 e- rms @ 1MHz
 - ~12 e- rms @ 5MHz
- **Gigabit Ethernet data interface**
 - High bandwidth data transmission

- Operate camera from more than 50 m (150 ft) away.
- **All digital design**
 - Independent signal paths to optimize performance of each port and readout speed.
 - The most comprehensive testing protocols to optimize multiple performance parameters at the same time.
- **Integrated shutter**
 - 25 mm integrated shutter for vignette free operation *or*
 - ability to directly drive an external shutter (no need for external shutter drivers)
- **Comprehensive Software support**
 - Use the renowned WinView/Spec under Windows 2000/XP
 - LabView SITK (Scientific Imaging Toolkit) with pre-defined Vis.
 - PVCAM universal interface for custom programming

3. How can ProEM achieve such low noise?

ProEM uses PINST[™] technology-the most advanced electronics of any CCD or EMCCD camera on the market today. It minimizes the electronic noise so that the ultimate noise performance is only limited by what the sensor can offer. Every readout port, speed is individually optimized for the best performance. The result is the noise performance is as much as 2x better than any competing designs in the industry. Now, you can see even the faintest of low light samples with clarity.

4. Why does ProEM offer slow speed such as 100 kHz readout?

The main benefit of EMCCDs is their ability to achieve <1 e⁻ rms noise at high frame rates. However, the use of multiplication or amplification causes excess noise which reduces the overall signal-to-noise ratio by a factor of 1.4. This might be acceptable for applications that require high frame rate (e.g., >30 fps) and have light levels below the read noise. However, for steady state applications that rely on very long exposures (e.g., seconds to minutes), the normal readout port offers the best SNR possible. Especially, the slowest readout rate such as 100 kHz allows read noise of ~ 3 e⁻ rms to be achieved which is close to the limits of the sensor preamplifier sensitivity.

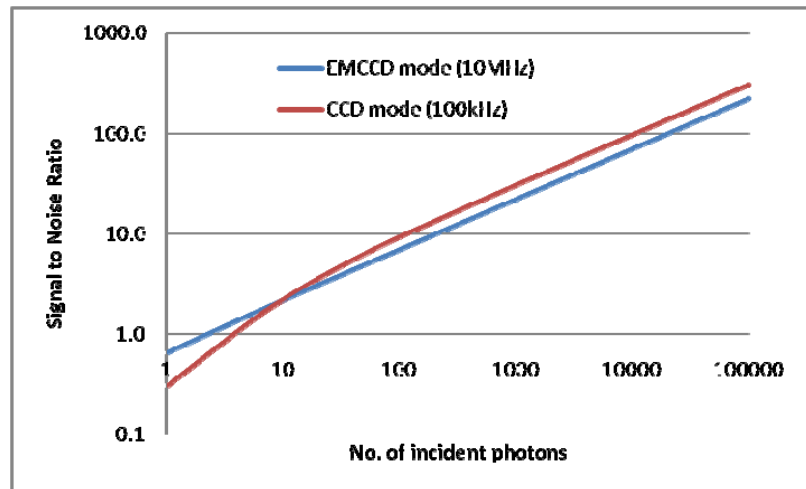


Figure: Comparison of SNR in Non-EM (100 kHz) and EM (10MHz) readout modes. Non-EM mode is ideal for slow speed imaging applications and offers higher signal to noise ratio

5. Any EMCCD camera achieves < 1 e- rms read noise with EM gain applied. Then, what is the advantage of lower read noise in ProEM?

It is true that all EMCCD cameras can achieve 1 e- rms read noise with EM gain applied for single photon sensitivity. However the amount of gain applied varies with the starting read noise of a given camera. For example, ProEM achieves the lowest read noise of 25 e- rms (@ 5MHz) in EM mode which is as much as 1.7x better than other EMCCD cameras. It requires only 25x EM gain to achieve 1 e- rms read noise. It is better as little gain as possible for the following reasons

- Lower EM gain degradation
- Preserve dynamic range –capture low light signals while preventing saturation of bright areas in the image.

6. What is OptiCAL™?

It is a method to calibrate the absolute electron multiplication (EM) gain of the ProEM camera. User can vary the real EM gain in precise linear steps. ProEM has a built-in, precision light source built in the nose of every camera for fast, precise calibration. Since the calibration is user accessible, it can be performed in the field without need for external light sources.

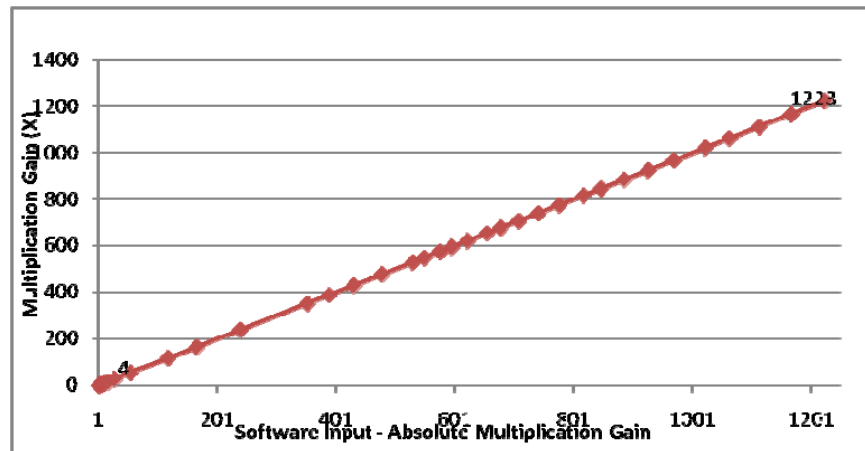


Figure: OptiCAL™ allows users to set the EM gain in absolute linear steps.

7. How can PI guarantee lifetime vacuum?

Princeton Instruments is the first and only company to guarantee lifetime vacuum performance. PI developed XP vacuum technology after years of research into ultra high vacuum (UHV) designs and production equipment. It involves eliminating materials that can cause out-gassing (slow release of gas molecules over time) and all-metal seals. In fact, even the vacuum window is brazed (brazing is a high temperature process by which two dissimilar materials are fused at molecular level). Each vacuum chamber undergoes a long vacuum process for more than five days and checked and rechecked with sensitive leak detectors to make sure that the seals are perfect. Only through such extensive experience and advanced facilities, a company can guarantee lifetime performance of its vacuum and cooling. Thousands of cameras based on this technology (PIXIS, PhotonMAX and XP cameras) that are already in the field are a testament to the PI's research, design and production capabilities.

8. What frame rates can be expected from ProEM?

ProEM offers 10MHz EM readout port for high frame rate applications. It can achieve >33 fps at full resolution (512x512) and >1000 fps at reduced ROI and binning. It has variable vertical shift rates and custom chip readout modes to further increase the frame rates by as much as 2x to 3x from standard ROI/binning modes. For full frame rate information, please refer to the datasheet.

9. What is "custom chip" mode?

"Custom chip" mode allows users to redefine the size of the active area right from the software. By ignoring the pixels outside the active area, the readout time is reduced. As a result, the

frame rate can be increased from the standard operation by up to 2 to 3 times when only a small region needs to be imaged. In order to effectively use the “custom chip” mode, the area outside the active area must be externally blocked from light. The following graph provides a sample frame rates that can be achieved by ProEM: 512B at 10MHz readout speed using both standard and custom chip readout modes.

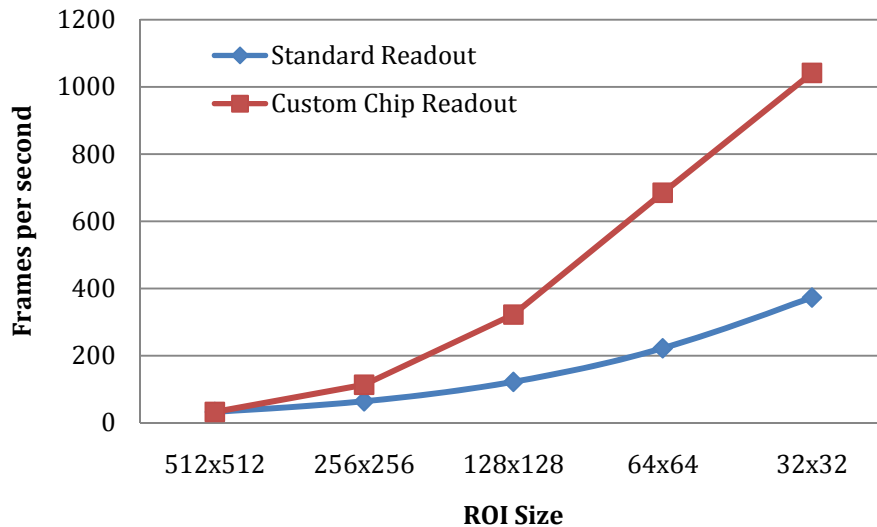


Figure: Frame rates of ProEM: 512B (10MHz) in standard and custom chip readout modes

10. What Binning modes are supported in ProEM?

ProEM has flexible binning in Y-direction. In X-direction, it has 1x, 2x, 4x, 8x, 16x and 32x in X-direction.

11. What are the mounting options available for ProEM?

ProEM comes with an adjustable c-mount –ideal for getting the best focus with lenses or ensuring par-focality on microscopes.

12. What is the purpose of integrated mechanical shutter?

ProEM uses frame transfer EMCCDs, which do not require mechanical shutter for normal operation. However, an integrated mechanical shutter can be used conveniently to capture reference dark images, to protect the sensor from debris or dust and during EM gain calibration procedure.

13. What types of cooling options are available for ProEM?

Every ProEM camera provides both air and liquid cooling options. Air cooling is provided by the integrated fan while the liquid assist can be provided by an external circulator.

14. What are the advantages of liquid (only) cooling option?

The innovative thermal design of ProEM allows users to turn off the fan completely and cool the detector using circulating liquid in vibration or heat sensitive environments. The liquid only cooling option has the following benefits

- Removes vibration from the camera head
- Eliminates thermal air currents that would cause smear from sensitive optics such as telescopes and microscopes.

By using a liquid circulator, the temperature of the CCD is maintained without adverse affects of internal fan.

Ability to turn off fan completely is superior to other options such as -temporarily shutting off fan as the latter could compromise temperature stability –a critical requirement for EMCCDs. As a result, when extended integration times or long sequences are captured

15. What type of vacuum window is used in the camera?

The standard vacuum window is a 3.17mm (0.125”) fused silica window. ProEM uses only one window in the light path that can be anti-reflective coated for the best throughput.

16. What are the options for AR coating the vacuum window?

UV, VIS and NIR anti-reflective AR coatings are available for the standard fused silica window. Following graph gives a comparison of transmission of windows with various AR coatings. MgF₂ window is available for deep UV applications. **IMPORTANT NOTE:** *The AR coatings are designed to give optimal performance over a specified wavelength region. However, outside this region, they may have much worse performance even compared to an uncoated window. So, care must be taken when specifying the AR coatings.*

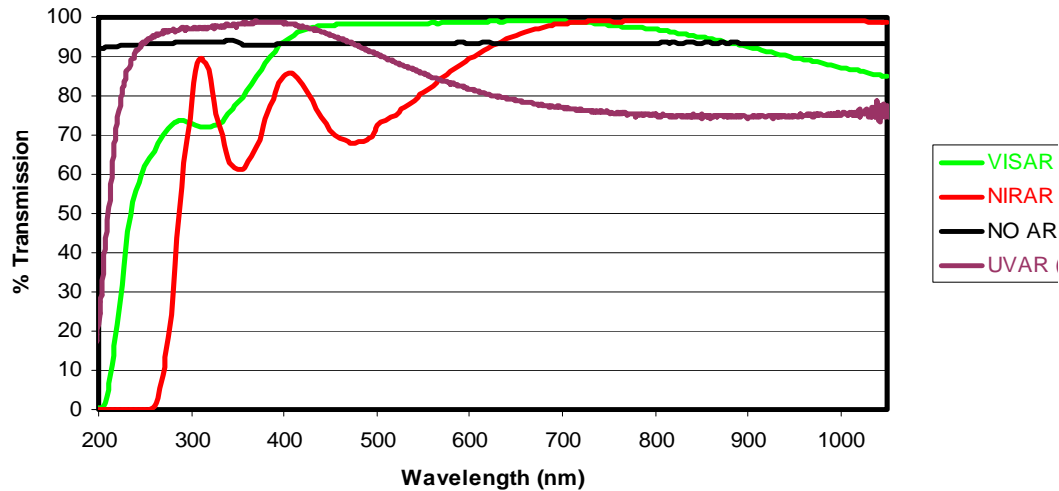


Figure 2: Available AR coating options for the vacuum window

17. What do I need to operate the ProEM camera?

ProEM comes with everything needed to run out of the box. It comes with c-mount w/shutter, power supply, gigabit Ethernet cable, gigabit Ethernet card and trigger cables. Users require a PC with XP (32-bit, SP3) operating system to run the camera. For enhanced performance, a fast hard drive (10,000 rpm) and 2GB RAM is recommended.

18. I need to operate the camera remotely. What are the options?

ProEM, with its GigE data interface, can be remotely operated from up to 50m or 150ft over standard Cat 5e/6 cables. For even longer distances, GigE-to-fiber optic converter boxes may be available that can extend the range to > 1km. Please contact factory for additional details.