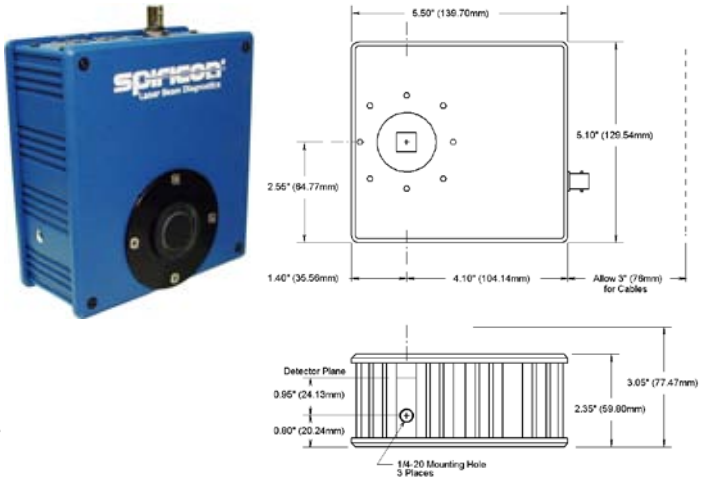
3.2.2 13-355nm and 1.06-3000µm - Pyroelectric Array Camera

Pyrocam™ III Series

Features

- Spectral ranges available from 13 to 355 nm and 1.06 to >3000 µm
- Image CO_2 lasers, telecom NIR lasers and other infrared sources out to Far IR THz sources
- Solid state array camera with 1000:1 linear dynamic range for accurate profiling
- Integrated chopper for CW beams and thermal imaging
- Versatile Firewire interface
- Interchangeable windows available for a variety of applications
- Image Viewer utility presents 3D isometric plots, 2D color contour plots and grayscale, among other views
- Includes BeamGage Laser Beam Analysis Software for extensive quantitative analysis and image display



Spiricon has been the world leader in the manufacture of pyroelectric solid-state detector arrays and cameras. For over 25 years the Pyrocam™ has been the overwhelming camera of choice for Laser Beam Diagnostics of IR and UV lasers and high temperature thermal imaging. Precision, stability, reliability, and versatility have become its proud heritage.

The Pyrocam™ III offers easy Windows® camera setup, direct Windows quantitative and image display, 14 bit digitizer, versatile Firewire® PC interface, an integral chopper for CW beams and thermal imaging, and many other enhanced features.

See Your Beam As Never Before

The Pyrocam™ III camera creates clear and illuminating images of your laser beam profile. Displayed in 2D or 3D views, you can immediately recognize beam characteristics that affect laser performance and operation. This instantly alerts you to detrimental laser variations. Instantaneous feedback enables timely correction and real-time tuning of laser parameters. For example, when an industrial shop foreman saw the CO_2 laser beam profile in Figure 1 he knew immediately why that laser was not processing materials the same as the other shop lasers, with the profile shown in Figure 2.

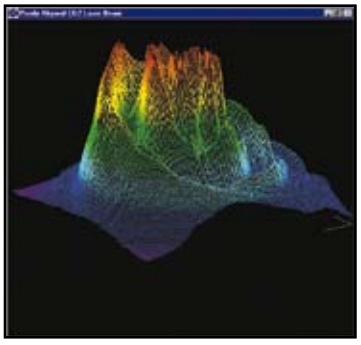


Fig. 1. Industrial CO_2 laser performing inconsistent processing.

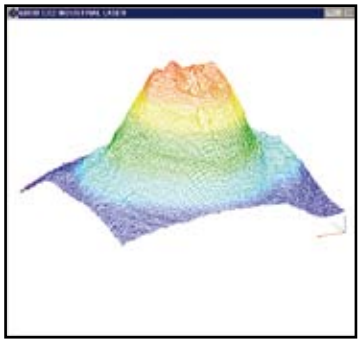


Fig. 2. Industrial CO_2 laser performing specifed processing.

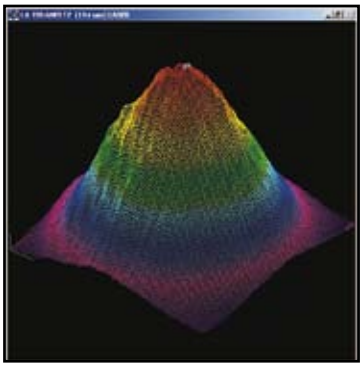
Pulsed and CW Lasers

The Pyrocam™ III measures the beam profile of both pulsed and CW lasers. Since the pyroelectric crystal is an integrating sensor, pulses from femtosecond to 12.8ms can be measured. The pyroelectric crystal only measures changes in intensity, and so is relatively immune to ambient temperature changes. Because CW laser beams must be chopped to create a changing signal, the Pyrocam™ III contains an integral chopper as an option.

Measuring Terahertz Beam Profiles

Spiricon's Pyrocam™ III pyroelectric camera is an excellent tool for measuring THz lasers and sources. The coating of the crystal absorbs all wavelengths including 1µm to over 3000µm (0.1THz to 300THz). For THz sources the sensitivity of the Pyrocam™ III is relatively low, at about 300mW/cm² at full output. With a S/N of 1000, beams of 30mW/cm² are easily visible.
In addition, with Spiricon's patented Ultracal baseline setting, multiple frames can be summed to "pull" a signal out of the noise. Summing 256 frames enables viewing of beams as low as 1-2mW/cm².

With Terahertz research suddenly being a central topic of interest, the Pyrocam™ III becomes an invaluable aid in this exciting research. Otherwise, scientists working on Terahertz research have no easy way to characterize the profile, or energy distribution, of their lasers or sources.



THz laser beam
at 0.2THz (1.55mm) 3mW input power;
19 frames summed.

Broad Wavelength Response

The Pyrocam™ III detector array has a very broadband coating which enables operation at essentially all IR and UV laser wavelengths. The curve ends at 100nm in the UV, but X-ray operation has been observed. Likewise the curve ends at 100µm in the far IR, but the camera has been used at >3000µm.

Thus you can use the Pyrocam™ III in the near IR for Nd:YAG lasers at 1.06µm, and for infrared fiber optics at 1.3µm and 1.55µm. Use the Pyrocam™ III for HF/DF lasers near 4µm and for Optical Parametric Oscillators from 1 µm to 10µm. It measures Free Electron Lasers between 10µm and 3000µm.
The Pyrocam™ III is extremely useful in the UV from 355nm to 157nm for Excimer lasers and for tripled or quadrupled Nd:YAG lasers. The detector is stable under UV illumination, without the deterioration experienced by CCD cameras. (The pyroelectric detector operates in the visible spectrum, and can see the alignment HeNe used with CO_2 lasers. However, spurious response from the underlying silicon multiplexer creates undesirable performance, and the camera is not recommended for quantitative visible measurements).

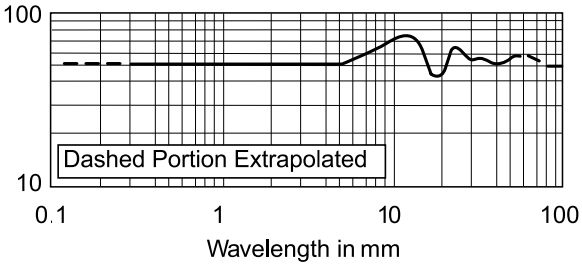
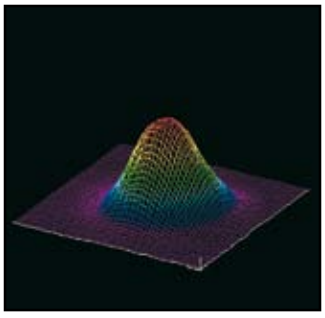
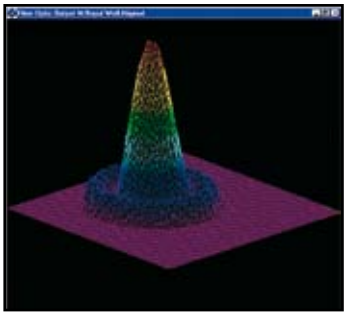


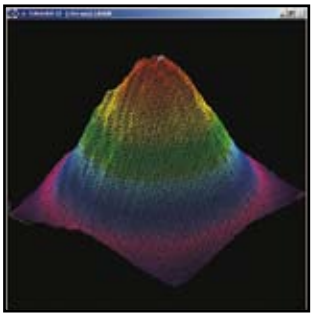
Fig. 6. Spectral response of Pyrocam™ III detector array without window.



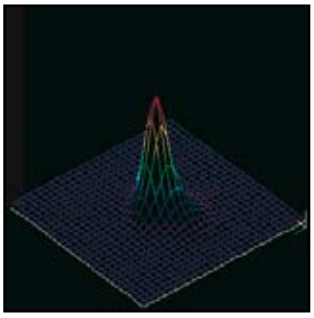
Er:YAG laser at 2.9µm.



Output of infrared fiber optic.



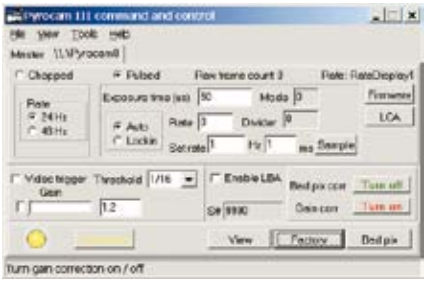
THz laser beam at 1.6THz (184µm).



Free Electron laser at 100µm.

Windows® PC Interface

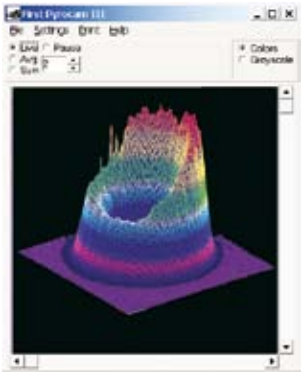
The Pyrocam™ III Windows application incorporates setup software to control all functions of the camera, such as pulsed versus chopped operation, gain, and background reference subtraction, eliminating all controls from the camera housing.



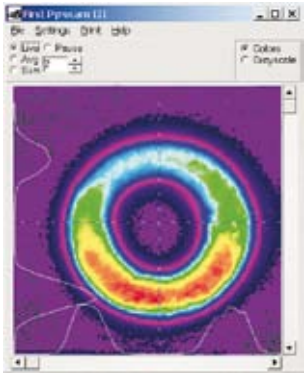
Pyrocam™ III Windows setup menu.

Windows Image Viewer

A Windows viewer application enables viewing of the laser beam in a number of modes, including 3D isometric plots, 2D color contour plots, and gray scale for thermal imaging. This application enables stand-alone operation of the camera independent of any other software. Nevertheless, the Spiricon BeamGage beam analysis software provides many additional features and capabilities not incorporated with the camera.



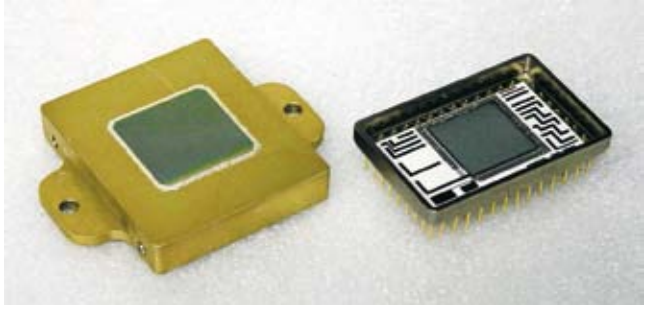
Composite Excimer LASIK beam profile at 193nm.



Composite Excimer LASIK beam profile in 2D display.

Hybrid Integrated Circuit Sensor

The Pyrocam™ III consists of a $LiTa0_3$ pyroelectric crystal mounted with indium bumps to a solid-state readout multiplexer. This sensor, developed for the Pyrocam I, has proven to be the most rugged, stable, and precise IR detector array available.
Light impinging on the pyroelectric crystal is absorbed and converted to heat, which creates charge on the surface. The multiplexer then reads out this charge onto the video line. For use with short laser pulses, the firmware of the camera creates a very short electronic shutter to accurately capture the thermally generated signal.



Pyrocam™ III sensor array and window assembly

State-Of-The-Art Electronics

The camera features a 14 bit A/D converter which digitizes deep into the camera noise. This enables reliable measurement and analysis of both large signals and low level signals in the wings of the laser beam. Fourteen bit digitizing also enables accurate signal summing and averaging to pull weak signals out of noise. This is especially useful with fiber optics at 1.3µm and 1.55µm, and in thermal imaging.

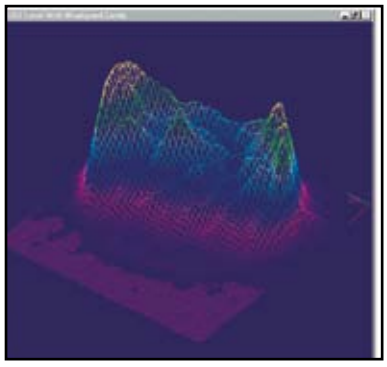
The Pyrocam™ III camera electronics incorporates 2 Firewire® (IEEE 1394A) interface ports. Multiple Pyrocam IIIs can be daisy chained together using the 1394 cabling.

New Housing & Chopper

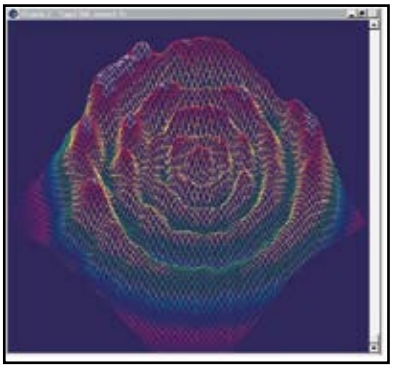
The Pyrocam™ III incorporates a new compact housing measuring only 5.5" high by 5.1" wide, and 2.5" deep in the direction of the beam path. This allows the camera to be inserted into smaller spaces on the optical table. It also makes the camera useful as a portable camera for thermal imaging and on-site field service of laser systems. The Pyrocam™ III integral focal plane chopper helps keep the camera head compact.

Applications Of The Pyrocam™ III

The Pyrocam™ III is an ideal camera for use in scientific laboratory investigation of laser beams. This includes physics, chemistry, and electronic system designs. As an example, the photos below show a research CO_2 laser and a research Nd:YAG laser, both with cavity misalignment.
The camera is also useful in product engineering of CO_2 and other infrared lasers. The Pyrocam™ III is an integral part of the assembly lines of many CO_2 laser manufacturers. Integrators of systems are using the Pyrocam™ sensor to make sure that optical systems are aligned and operating properly.

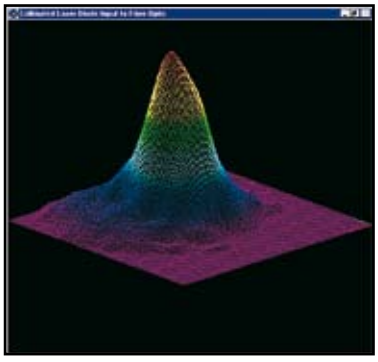


CO_2 laser with cavity misalignment.

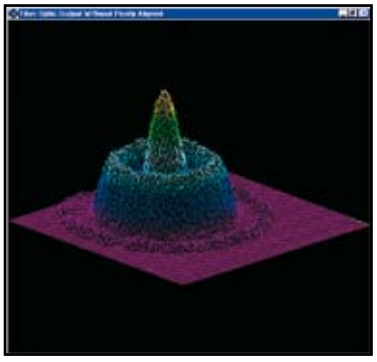


Nd:YAG laser with cavity misalignment.

There are many medical applications of the Pyrocam™ III, such as the analysis of excimer lasers used for eye surgery. In many cases these lasers need alignment to ensure that the eye surgery is performed as expected. Other medical IR lasers perform dermatology, for which the uniformity of the beam profile must be assured.
Fiber optic communications, at 1.3µm and 1.55µm make significant use of the Pyrocam™ III for analyzing the beams being emitted, as well as analyzing properties of the beams before launching them into fibers. The greater stability of the Pyrocam™ III make it a good choice over other cameras operating at telecommunication wavelengths.



CO_2 laser with cavity misalignment.

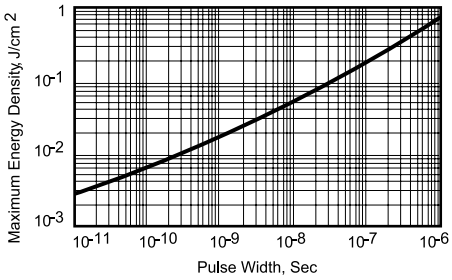


Nd:YAG laser with cavity misalignment.

The Pyrocam™ III is becoming an essential tool in the maintenance of industrial infrared lasers, especially CO_2. The Pyrocam™ III replaces non-electronic mode burns and acrylic blocks by providing higher definition electronic recording of data, and analysis of short term fluctuations. The Pyrocam™ III is superior to other electronic methods of measuring CO_2 lasers because the entire beam can be measured in a single pulse, and additional measurements made in real-time. This ensures that the beam did not change during the measurement.

Detector Damage Threshold

The Pyrocam™ III sensor is capable of operation with intensities about 106 times greater than CCD cameras. This makes the camera ideal for use with high power lasers, as less attenuation is required. Nevertheless, pulsed lasers with fluence too high can evaporate the absorbing front electrode.



Pulsed damage threshold of pyroelectric detector coating.

As shown the damage threshold increases with pulse width. With nanosecond and longer pulses, detector saturation occurs before damage. With shorter pulses it helps to increase the camera amplifier gain so that electronic saturation occurs before damage.

The sensor can be damaged by excessive CW power, which causes crystal cracking. Very few Pyrocam™ III detectors have been damaged by CW power, but some have been ablated by high peak pulse energy.

GENERAL SPECIFICATIONS FOR PYROCAM™ III

Application	UV and IR
Spectral response	13 - 355nm
	1.06 - 3000µm
Interchangeable windows	See selection in Ordering Information section
Active area	12.4mm x 12.4mm
Element spacing	100µm x 100µm
Number of elements	124 x 124
Pixel size	85µm x 85µm
CHOPPED CW OPERATION	
Chopping frequencies	24Hz
Optional chopper	48Hz
Sensitivity (RMS noise limit)	220 nW/pixel (24Hz)
	320 nW/pixel (48Hz)
	2.2 mW/cm² (24Hz)
	3.2 mW/cm² (48Hz)
	45 nW/Hz1/2/pixel (1Hz)
Noise equivalent power (NEP)	2.2W/cm²(24Hz)
Saturation power	3.2W/cm² (48Hz)
Damage total power	
Over entire array	2W
Power density	8W/cm²
PULSED OPERATION	
Laser pulse rate	Single-shot to 1000Hz
Pulse width	1fs - 12.8ms
Sensitivity (peak noise limit)	7nJ/pixel
	70µJ/cm²
Saturation energy	10mJ/cm²
Damage threshold	20mJ/cm² (1ns pulse)
	600mJ/cm² (1 µs pulse)
OPERATING CONNECTIONS AND CONDITIONS	
Power	120/230 VAC
	60/50Hz External Supply
Operating temperature	5°C to 50°C
PHYSICAL DIMENSIONS	
Case Dimensions	140mm H X 130mm W X 62mm D
Detector Position	Centered in width
	35.6mm from bottom
	15.2mm behind front cover (without included C-mount attached)
Weight	1.52Kg
MEASUREMENTS PERFORMED BY THE WINDOWS IMAGE VIEWER	
Total power or energy in digital counts or calibrated in software	
Peak power or energy in digital counts or calibrated in software	
Peak location in µm	
Centroid location in µm	
Diameter at 1/e2 points in µm	
X & Y Knife edge beam widths in µm	
USING BEAMGAGE	
Extensive set of quantitative and image display capabilities. See BeamGage data sheet.	

FEATURES

- 14 bit digital output in CW, 13 bit digital output in pulsed
- More critical A & B grading criteria

Grade A Up to 50 bad pixels, all correctable
No uncorrectable clusters

Grade B Up to 100 bad pixels
No uncorrectable clusters within the 70% central area, no more than 2 outside

- Compact Head 5.53"HX5.13"WX2.53"D
- Internal integrated focal plane chopper for CW (24 & 48Hz). No separate controller
- Lens mount and internal focal plane chopper for IR imaging
- Two Firewire® interface ports to PC computer (IEEE 1394a)

GENERAL SPECIFICATIONS FOR PYROCAM™ III

FEATURES
▪ Firewire to PCI adapter
▪ Windows image viewer
2D and 3D beam display
Readout externally calibratable for energy or power
Frame averaging and summing for low level signal analysis
Data logging
Manual gain setting
Plus calculations previously provided
X & Y width
Centroid location
Peak location
Total power or energy in digital counts
▪ Windows setup menu (control console - no buttons or knobs, more user friendly)
▪ High speed, up to 1kHz standard
▪ Automatic lock in to pulse trigger rate
▪ Programmable exposure time (to reduce signal loss from thermal spread) 50µs to 12.8ms in 50µs increments
▪ Slider for fine adjustment gain settings; 1X to 10X CW, 6X Pulse
▪ User enabled bad pixel correction
▪ Separate bad pixel correction for pulsed and CW
▪ User enabled gain correction - separate for pulsed and CW
▪ Internet field upgradeable firmware
▪ Interface to 3rd party software via ActiveX
▪ Export images in .bmp or ASCII file format

Ordering Information

Item	Description	P/N
Pyrocam III Beam Profiler Systems		
PY-III-P-A	Pyroelectric array detector, pulsed only, Grade A, two FireWire ports, and basic viewer software. BeamGage Standard included. To complete this order, you must add an Interchangeable Window part number to accompany this system (see below).	SP90090
PY-III-P-B	Pyroelectric array detector, pulsed only, Grade B, two FireWire ports, and basic viewer software. BeamGage Standard included. To complete this order, you must add an Interchangeable Window part number to accompany this system (see below).	SP90091
PY-III-C-A	Pyroelectric array detector, chopped and pulsed, Grade A, two FireWire ports, and basic viewer software. BeamGage Standard included. To complete this order, you must add an Interchangeable Window part number to accompany this system (see below).	SP90092
PY-III-C-B	Pyroelectric array detector, chopped and pulsed, Grade B, two FireWire ports, and basic viewer software. BeamGage Standard included. To complete this order, you must add an Interchangeable Window part number to accompany this system (see below).	SP90093
Interchangeable Windows for Pyrocam III (one included free with the purchase of a Pyrocam III Beam Profiler System)		
PY-III-W-BK7-1.064	Pyrocam III Window BK7 A/R coated to 1064nm	SP90101
PY-III-W-Si-1.05-2.5	Pyrocam III Window Silicon A/R coated to 1.05 - 2.5µm	SP90102
PY-III-W-Si-2.5-4	Pyrocam III Window Silicon A/R coated to 2.5 - 4µm	SP90103
PY-III-W-Ge-3-5.5	Pyrocam III Window Germanium A/R coated to 3 - 5.5µm	SP90104
PY-III-W-Ge-10.6	Pyrocam III Window Germanium A/R coated to 10.6µm	SP90105
PY-III-W-Ge-8-12	Pyrocam III Window Germanium A/R coated to 8 - 12µm	SP90106
PY-III-W-ZnSe-10.6	Pyrocam III Window Zinc Selenide A/R coated to 10.6µm	SP90107
PY-III-W-ZnSe-2-5	Pyrocam III Window Zinc Selenide A/R coated to 2 - 5µm	SP90108
PY-III-W-Poly-THz	Pyrocam III Window Polyethylene uncoated for Tera-Hz wavelengths	SP90208