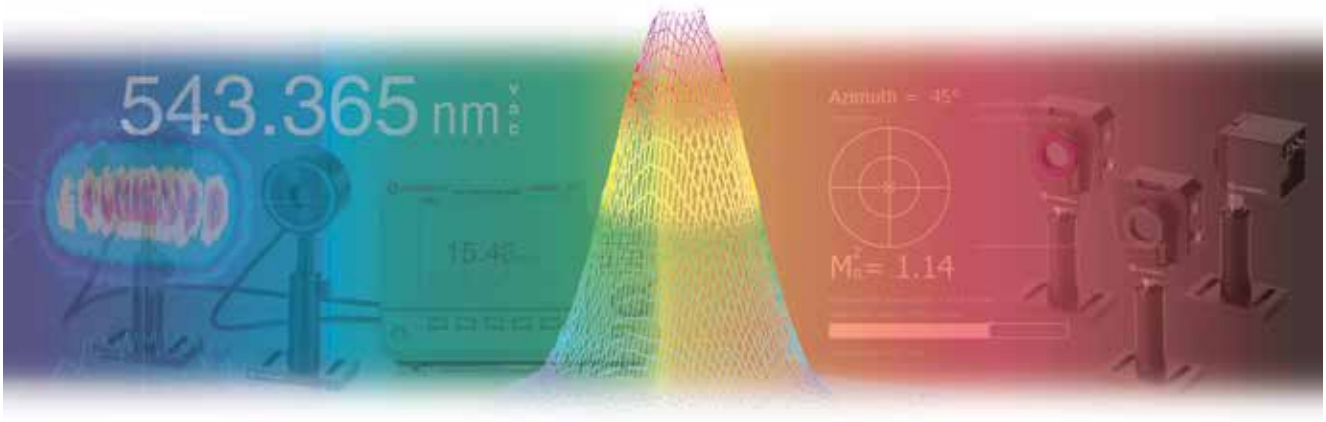
Beam Diagnostics Introduction

Introduction to Laser Beam Diagnostics

In today's fast-paced photonics market it is important to understand the technical specifications of highly complex laser systems and their applications. As well as analyzing the power or energy, it is also useful to understand the shape, intensity profile, and propagation of a laser beam. For over 25 years Coherent has developed precision instruments that measure, characterize, and monitor these laser parameters for thousand of customers around the world.



Beam Profilers

As a laser beam propagates, changes in the laser cavity, as well as changes in divergence and interactions with optical elements, cause the width and spatial intensity of the beam to change in space and time. Spatial intensity distribution is a fundamental parameter for indicating how a laser beam will behave in any application. And while theory can sometimes predict the behavior of a beam, tolerance ranges in mirrors and lenses, as well as ambient conditions affecting the laser cavity and beam delivery system, necessitate verification.

Two types of beam profilers are available: those that use special cameras as the beam detectors (these are excellent for fast and detailed analyses of the intensity profile of pulsed and CW lasers); and systems that use moving knife-edges (these have a large dynamic range and can accurately measure small and focused beams). Coherent has both of these types available: the camera-based LaserCam-HR on pages 95 to 96 and an advanced knife-edge system—BeamMaster—on pages 107 to 109.

Beam Propagation

The Coherent ModeMaster beam propagation analyzer established an entirely new laser beam quality parameter that is now an ISO standard. M^2 is recognized as describing both how "close-to-perfect Gaussian" a beam is, and also how well the beam can be focused at its intended target.

Wavelength Meter

For many high performance tunable laser systems, or those using laser diodes, it is important to measure the wavelength. The WaveMaster laser wavelength meter accurately measures the wavelength of both CW and pulsed lasers of any repetition rate to an accuracy of 5 picometers. See page 116 for additional specifications for the WaveMaster.

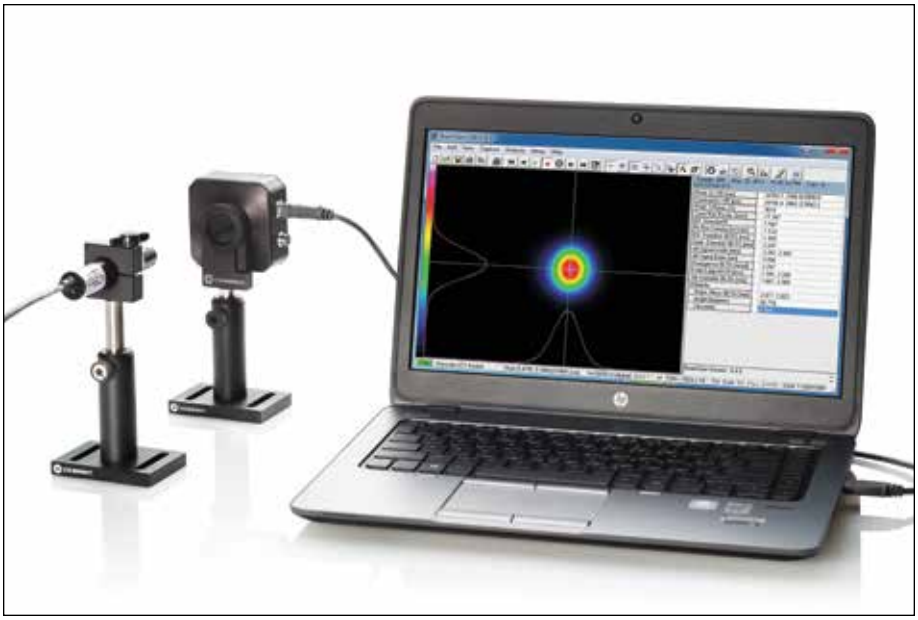
Summary of Product Primary Measurement Capabilities

Model	BeamView Analyzer	BeamMaster	ModeMaster	WaveMaster
Wavelength	–	–	–	CW + Pulsed
Power	–	CW	–	–
Beam Position	CW + Pulsed	CW	CW	–
Propagation M^2	–	–	CW	–
Beam Profiles				
2D	CW + Pulsed	CW	CW	–
3D	CW + Pulsed	CW	–	–
Page Number	98	107	110	116

LaserCam-HR II

Introduction to Camera-Based Beam Diagnostics

Coherent BeamView Analyzer systems are the recognized leader in software, hardware and optical components for laser beam analysis. Constant product improvement based on customer feedback, and innovation from beam analysis experts, have made BeamView Analyzer products the first choice for laboratory, factory and field measurements.



The key elements of a typical camera-based beam profiling system are the camera itself, Coherent Beamview analysis software running on an appropriate computer and, when necessary, beam attenuation optics. The key choice to make is matching the appropriate camera technology to your application.

Coherent beam diagnostic cameras are specifically designed or modified for laser analysis. They provide low noise, maximum linearity, and uniformity of response—needed for maximum measurement accuracy. All of these diagnostic cameras accept C-Mount optical accessories and are delivered without a cover (glass/plastic window) over the sensor array. Instead, a LDFP (Low-Distortion Face Plate) filter is supplied with each camera—a laser-grade neutral density filter made of glass specified and polished specifically for laser diagnostic analysis. The LDFP filter is mounted in a standard C-Mount ring and provides attenuation of ambient room light so that the camera can be used with normal room lights.

USB 2.0 Beam Diagnostic Camera Family

Coherent pioneered the ease-of-use of digital USB 2.0 bus-powered, high-resolution, large area cameras requiring only a single cable for both video transfer and camera power. The LaserCam-HR family of beam diagnostic cameras includes the LaserCam-HR II CCD cameras, the LaserCam-HR-UV and the LaserCam-HR-InGaAs models, covering the measurement spectrum from the deep ultraviolet to the near-infrared wavelengths.

With a broad spectral range covering 190 nm to 1700 nm, there is a LaserCam-HR camera profiler system ideally suited for nearly any demanding laser measurement application including scientific, excimer lasers, telecommunications sources, and military laser systems.

Important Considerations

- Ease-of-use connectivity
  - High-speed USB 2.0 Interface
  - USB bus-powered low voltage operation
- Broad spectral range
  - LaserCam-HR II — 190 nm to 1100 nm (400 to 1100 nm with LDFP) (190 to 355 nm with BIP-12F)
  - LaserCam-HR-UV — DUV to 355 nm
  - LaserCam-InGaAs — 900 nm to 1700 nm
- Large dynamic range
- Digital output through USB 2.0 eliminates the need for an interface card (frame-grabber)
- High-accuracy beam diameter calculations
- Excellent beam spatial uniformity
- Variable camera exposure time
- Compact size
- High-speed image capture rates (15 to 25 frames per second)
- Pass/Fail TTL level output
- RS-232 and TCP/IP communication protocols
- All LaserCam-HR camera systems are RoHS compliant

Multiple channel camera support of different LaserCam-HR camera models is available for all three LaserCam-HR camera types (UV, visible, and InGaAs).

Variable camera exposure time available with the entire LaserCam-HR camera family allows imaging of higher repetition rate sources and lets the user decrease/increase the signal intensity levels using exposure time instead of external attenuation. This feature is especially suited for the LaserCam-HR-InGaAs, with its impressive spatial uniformity characteristics.

Beam Diagnostic Cameras

LaserCam-HR II and LaserCam-HR-UV

LaserCam-HR II

LaserCam-HR-UV

Features

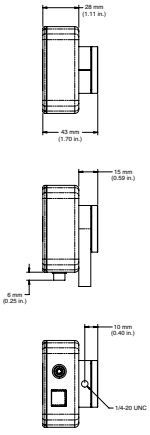
- USB 2.0, 10-bit to 14-bit digital output
- Large area arrays
- Compact 68 x 68 x 34 mm package
- Metric and English mounts included
- CW and pulsed operation including external triggering
- Variable exposure time and trigger delay
- Long-term UV sensor stability (with the LaserCam-HR-UV camera)
- C-mount thread for additional accessories

Device Specifications

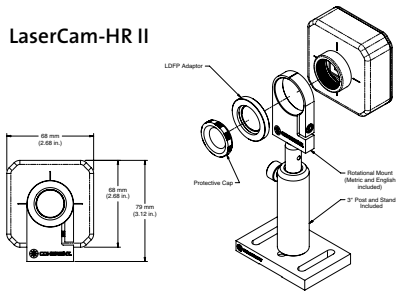
**C24

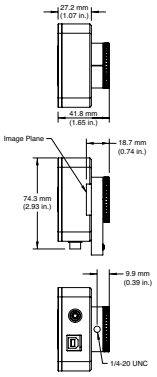
Model	LaserCam-HR II 1/2-inch	LaserCam-HR II 2/3-inch	LaserCam-HR-UV
Sensor Elements (pixels)		1280 x 1024	
Effective Pixel Resolution (µm)	n/a	n/a	20 x 20
Pixel Size (µm)	4.6 x 4.6	6.5 x 6.5	n/a
Sensor Active Area (mm)(H x V)	5.9 x 4.8	8.3 x 6.6	8.5 x 6.8
Camera Bit Depth	12-bit	14-bit	10-bit
Spectral Range (nm)			
without LDFP	190 to 1100[1]	190 to 1100[1]	190 to 355
with LDFP included	400 to 1100	400 to 1100	
with BIP-12F accessory	190 to 355	190 to 355	
Recommended Beam Diameters (mm)	0.15 to 4.0[2]	0.2 to 6.0[2]	0.5 to 6.0
Capture Modes		Continuous (CW), pulsed	
Variable Exposure Time	1 msec to 500 msec, default at 5 msec	1 msec to 500 msec, default at 5 msec	1 msec to 1 sec, default at 10 msec
Trigger Delay (µs)	75	20	160
Maximum Pulse Trigger in Rate[3] (Hz)	200	200	100
Damage Threshold			
without LDFP	32 mJ/cm² at 1064 nm	32 mJ/cm² at 1064 nm	200 µJ/cm² at 1064 nm[4]
CW Saturation			
with LDFP	13 mW/cm² at 633 nm	5 mW/cm² at 633 nm	90 mW/cm² at 248 nm[5]
without LDFP	5 µW/cm² at 633 nm	2 µW/cm² at 633 nm	90 µW/cm² at 248 nm[4]
with LDFP	70 mW/cm² at 1064 nm	25 mW/cm² at 1064 nm	
without LDFP	340 µW/cm² at 1064 nm	125 µW/cm² at 1064 nm	
Pulsed Saturation			
with LDFP	0.4 mJ/cm² at 1064 nm	0.15 mJ/cm² at 1064 nm	
without LDFP	2 µJ/cm² at 1064 nm	0.7 µJ/cm² at 1064 nm	
USB 2.0 Cable		10 ft. standard A/B cable included	
Trigger		Connector BNC receptacle (trigger cable included)	
Part Number	1282868	1282870	1149004

[1] There is a risk of degradation in the range of 190 nm to 300 nm due to DUV exposure. The optional BIP-12F (p. 106) UV-to-visible fluorescence converter can be used to prevent drift.
[2] It is possible to measure beams <0.2 mm in diameter, but resolution is reduced.
[3] Without averaging adjacent pulses.
[4] Without LDFP-UV.
[5] With LDFP-UV.
** C24 Quick Ship program: eligible for next business day shipment.

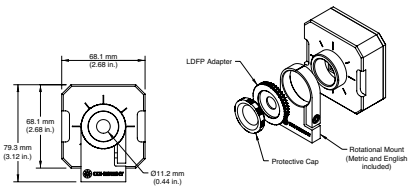


LaserCam-HR II





LaserCam-HR-UV



Beam Diagnostic Cameras

LaserCam-HR-InGaAs

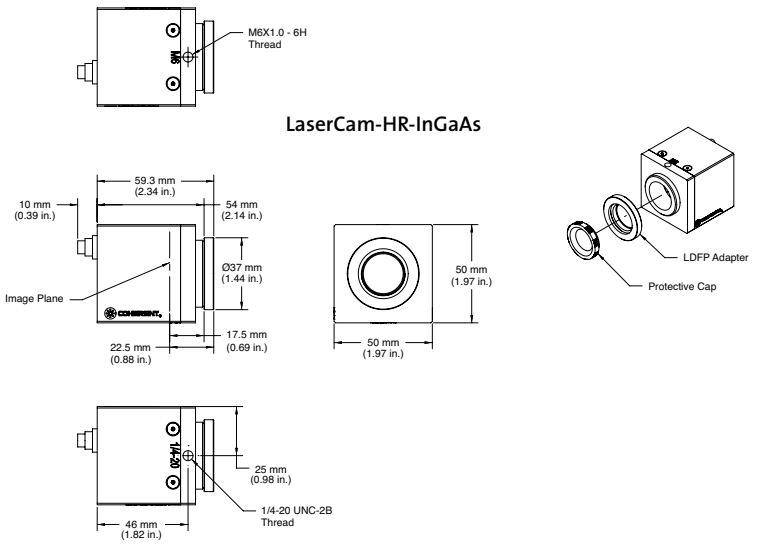
LaserCam-HR-InGaAs

Features

- USB 2.0 large area, InGaAs sensor, 9.6 mm x 7.7 mm
- 14-bit digital output providing >1000:1 optical dynamic range
- Outstanding linearity error of <1%
- 30 µm x 30 µm pixel pitch
- Compact 50 x 50 x 68 mm package
- CW and pulsed operation including external triggering
- Coherent Adaptive Pixel Technology (CAPT) pixel-by-pixel offset, linearity and blemish correction
- Variable exposure time, 20 µsec to 25 msec
- User variable trigger delay
- C-mount thread for additional accessories

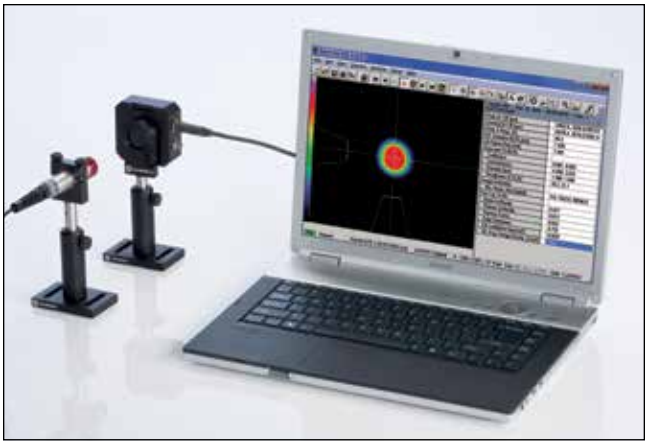
Device Specifications

Model	LaserCam-HR-InGaAs
Sensor Elements (pixels)	320 x 256
Pixel Size (µm)	30 x 30
Sensor Active Area (mm)(H x V)	9.6 x 7.7
Spectral Range (nm)	900 to 1700
Beam Diameters (mm)	0.5 to 6.0
Glassless Sensor	Low Distortion Face Plate is removable
Low-Distortion Face Plate (LDFP)	Laser-grade ND filter, OD = 2.5 at 632.8 nm
Electrical Interface	USB 2.0
Capture Modes	Continuous (CW), pulsed
Variable Exposure Time	20 µsec to 25 msec, default at 1 msec
Pulsed Mode Trigger Methods	Trigger In (TTL)
Maximum Frame Rate (FPS)	25 (live video, no calculations), 15 (capture with calculations)
Saturation	
CW (at 1064 nm)	3.5 mW/cm² (with LDFP), 50 µW/cm² (without LDFP)
CW (at 1523 nm)	350 µW/cm² (with LDFP), 30 µW/cm² (without LDFP)
Pulse (at 1064 nm)	5 µJ/cm² (with LDFP), 0.08 µJ/cm² (without LDFP)
USB 2.0 Cable	6 ft. standard A/B cable included
Trigger Connector	BNC receptacle (trigger cable included)
Part Number	1149002



BeamView Analyzer Software

Introduction to BeamView-USB Software



To monitor, analyze and archive laser beam images, BeamView Analyzer software is recognized as the leading laser beam profiling software. It has been designed to provide flexibility, speed, and user friendliness.

Features

- **High-speed USB 2.0 camera interface**
- **Supports all three LaserCam-HR camera types**
- **Remote control interface**
- **Over 30 numerical analysis functions**
- **Multiple image import and export formats**
- **Automatic background noise subtraction**
- **Pass/Fail fault settings, alarms, configurable setups**
- **Easy-to-use, intuitive user interface**
- **Windows XP, Vista 32-bit, Vista 64-bit, Windows 7 32-bit, Windows 7 64-bit**

POWER & ENERGY
Power & Energy Meters
USB/RS Power Sensors
DB-25 Power Sensors
USB/RS Energy Sensors
DB-25 Energy Sensors
Custom & OEM
BEAM DIAGNOSTICS
CALIBRATION & SERVICE
Laser Cross-Reference Index
Model Name Index

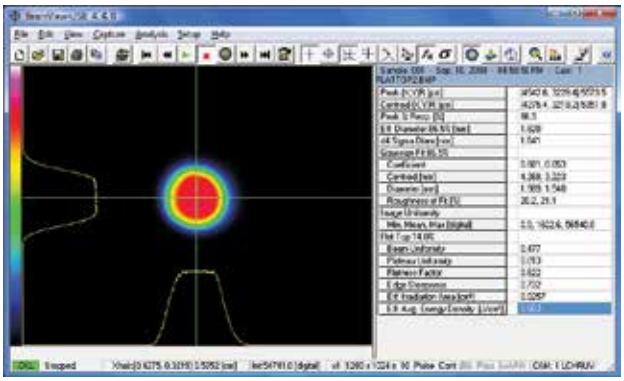
BeamView-USB Analyzer Software

BeamView-USB Analyzer Software
BeamView-USB software includes features that extend the analytic capabilities of the LaserCam-HR laser beam diagnostic systems:

- Supports both 10-bit and 14-bit LaserCam-HR camera types
- Multiple LaserCam-HR camera types can be connected to a single system
- Flat-top beam analysis
- Adjustable trigger delay
- Report generation
- Variable exposure time
- RS-232 and TCP/IP remote communication protocols

Flat-Top Beam Analysis
Six additional calculations are now available with BeamView-USB software for flat-top beam analysis. These calculations are based on the ISO 13694:2000 standards. The six calculations allow greater flexibility for the analysis of applications involving flat-top beam shapes. They also may assist in the analysis of beam uniformity of excimer and Nd:YAG lasers in the near field. The six new calculations are:

- Plateau Uniformity
- Flatness Factor
- Edge Steepness
- Beam Uniformity
- Effective Irradiation Area
- Effective Average Power/Energy Density



Screen shot of a flat-top beam image

Image of dialog box for flat-top calculations.

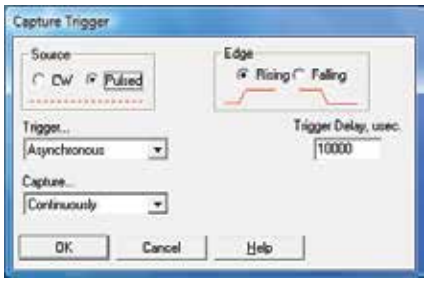
BeamView Analyzer Software

BeamView Analyzer Software Features

Adjustable Trigger Delay
The adjustable Trigger Delay feature lets users add default trigger delay to the LaserCam-HR camera. This assists by providing additional flexibility when firing the camera from an external trigger source such as the SYNC Output of a laser.

Adjustable Exposure Time
The camera exposure time is adjustable through the camera settings menu for all LaserCam-HR camera models.

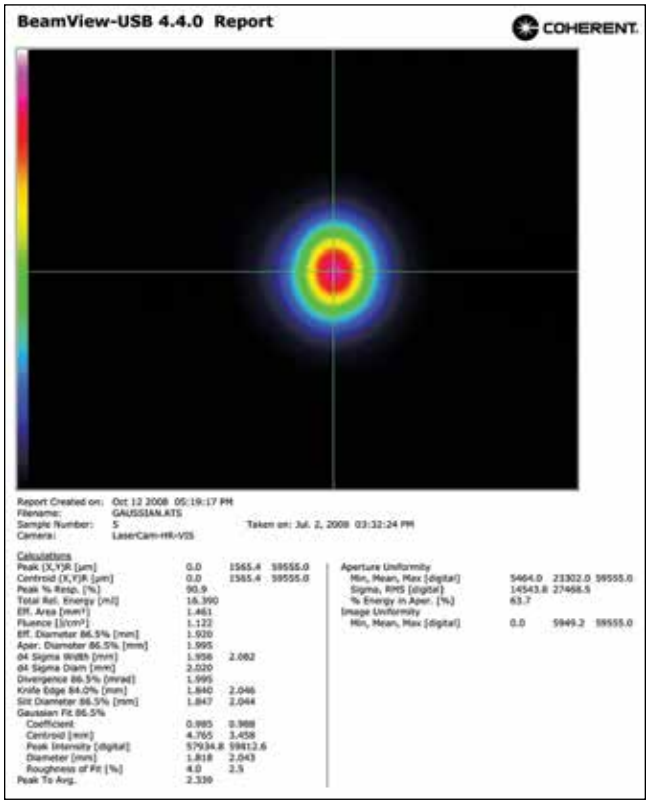
Report Generation
BeamView-USB includes a single-page report that can be sent directly to a printer, saved to a file (.txt), or converted to an Adobe .pdf file by using a pdf file converter. A simple screen print option is available from the same friendly dialog box used to generate a report.



Screen shot of Capture/Trigger dialog box showing Trigger Delay setting

BeamView System Performance Optimization

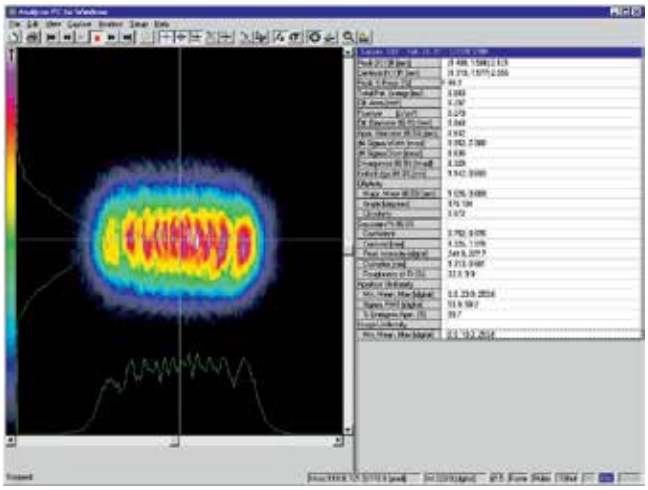
BeamView software provides several functions that optimize the optical dynamic range available in the camera to achieve maximum measurement accuracy. The Automatic Background subtraction feature measures and stores the background noise "image" and automatically subtracts individual pixel noise levels from all subsequent laser images prior to analysis. The system also automatically monitors the background noise level to warn of changes that may effect measurement accuracy.



Screen shot of Print Screen dialog box and actual report

BeamView Analyzer Software

BeamView Analyzer Software Features

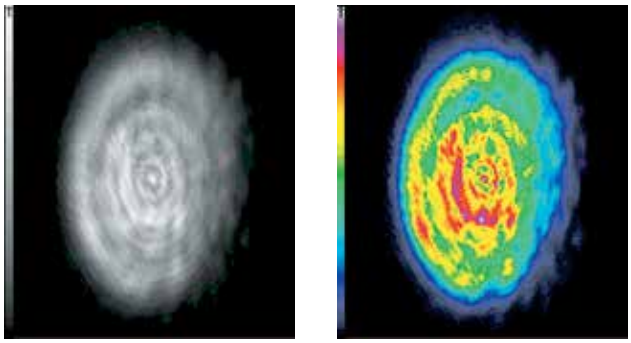


BeamView Analyzer Software Additional Features

- **More than 25 different numerical analysis functions**
- **Several different profile views**
- **Import and export of results data and profile data**
- **Pass/Fail settings and user-selectable fault actions**

Real-Time Laser Monitoring and Alignment

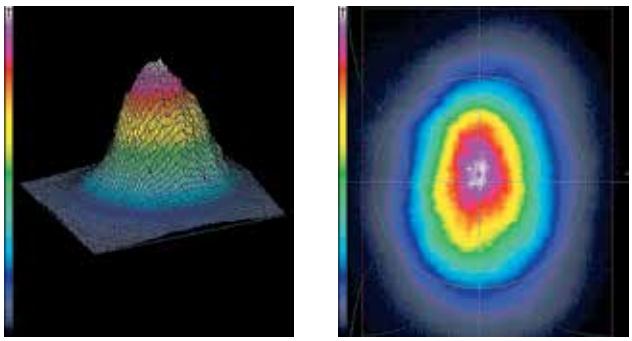
The Live Video mode provides a continuously updated image of the beam (~20 Hz to 25 Hz, depending on the speed of the processor) displayed in shades of gray or pseudo-color. This mode is ideal for monitoring the laser and observing changes in the form and structure of the beam as it is adjusted. It also allows for real-time tuning to achieve optimum beam profile quality and laser-cavity alignment. While operating in this mode, no beam or statistical data are displayed, but if Run is activated, the image is stored and can be analyzed later.



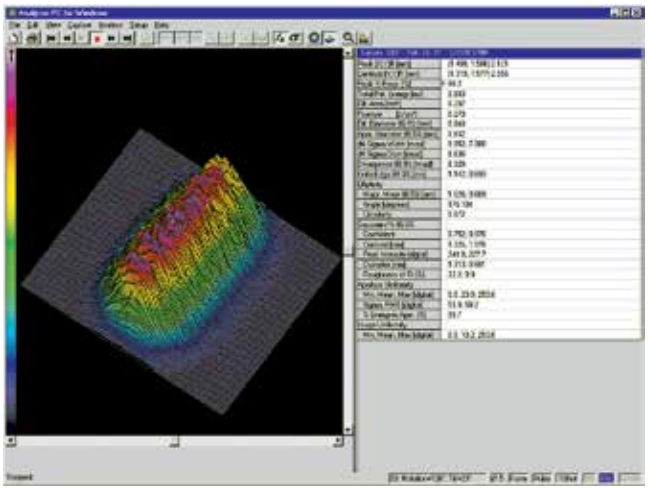
The Live Video mode

2D and 3D Intensity Plots

The Run command switches the BeamView Analyzer from the Stop or Live Video mode to continuous operation, which provides capture, analysis and display of beam image data. The view area of the computer monitor provides a choice of 2D or 3D images. The 2D contour maps and the 3D isometric plots display laser beam intensity profiles in a choice of color and gray-scale styles (fixed and autoscaling to a peak) and sizes (continuous zoom and pan control). The 2D maps can be shown with or without profiles (and Gaussian fit), reference position, variable aperture and rotatable crosshairs (with auto peak and auto centroid location). The 3D isometric plots can be displayed with transparent, hidden or solid wires, and can be rotated and viewed from different tilt angles.



Choice of 3D and 2D images



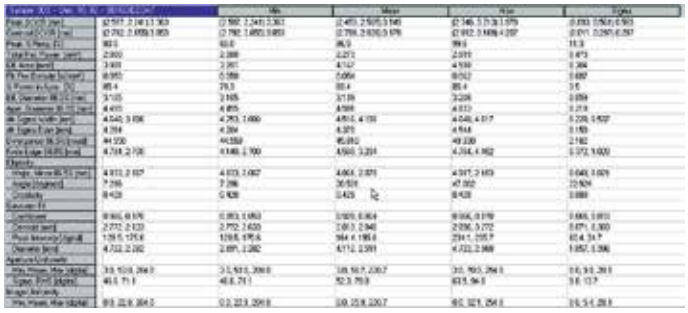
BeamView Analyzer display with 3D image and ISO-compatible results

BeamView Analyzer Software

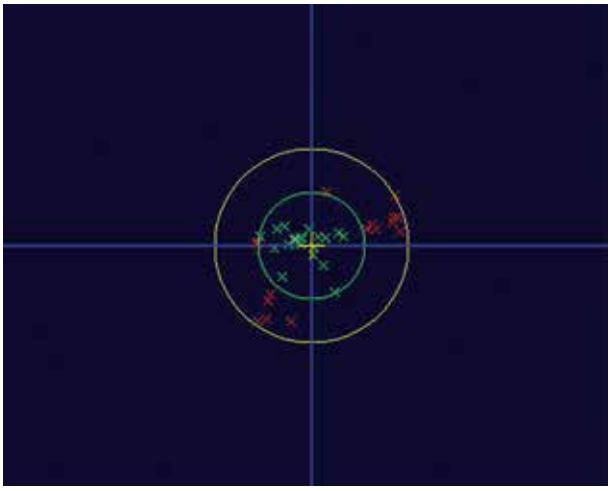
BeamView Analyzer Software Features

Beam Stability

The continuous on-line statistical analysis display shows results of all, or a combination of, functions and pass/fail parameters for all captured samples and accumulated results. The user can scroll through the analysis results of individual images, and also view the minimum, maximum and sigma (standard deviation) values. This makes comparing individual samples to the time-dependent statistical data easy. Thus, the jitter and stability of parameters, such as power, energy, pointing direction, ellipticity and beam size, etc., can be analyzed simultaneously with a polar beam wander plot.



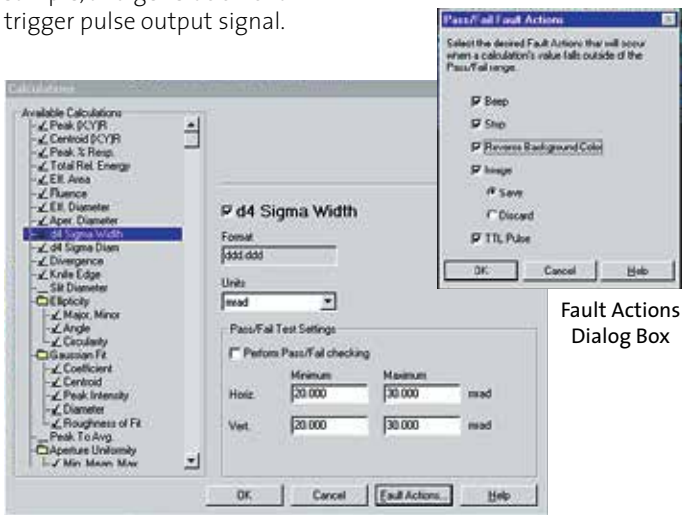
Continuous on-line statistical analysis display



Polar beam wander plot screen

Pass/Fail Analysis

Pass/fail analysis allows simultaneous real-time monitoring of all, or any one of the analysis results against user-specified minimum/maximum limits. Any combination of, or all the fault actions can be activated to signal a test failure, initiate a visual alarm, an audio alarm, stop data capture, reject/save a failed sample, and generation of a TTL trigger pulse output signal.



Fault Actions Dialog Box

Calculations Pass/Fail test settings

Remote Control

The BeamView Analyzer provides remote control and data transfer through a TCP/IP or RS-232 connection on the host computer. A complete control and data transfer command set is provided to allow users to develop their own remote control application for interfacing with the BeamView Analyzer software platform. The BeamView-USB software package includes an example LabVIEW VI for remote access to most BeamView features at a host computer running LabVIEW.

Beam Analysis and Statistics

BeamView Analyzer software calculations are compatible with the International Standards Organization (ISO) guidelines for laser beam measurement:

- Peak and centroid beam position
- Beam ellipticity including angular position and major/minor axis information
- Circularity
- D4σ diameters and widths
- Guassian fit including coefficient, centroid, and "roughness of fit"
- Aperture fit and uniformity
- Total/relative power
- Peak power/energy density
- Percent power within an aperture

BeamView Analyzer Software

BeamView Analyzer Software Features Summary

Analysis, On-Line Pass/Fail Tests

- **Centroid position/wander**
- **Peak intensity/position**
- **Peak-to-average intensity**
- **Beam diameter/widths (selectable):**
  - Second moment (d4 Sigma)
  - Knife-edge
  - Slit
  - Aperture diameter
  - Effective diameter
- **Flat Top analysis (new in BeamView-USB 4.4):**
  - Beam uniformity
  - Plateau uniformity
  - Flatness factor
  - Effective irradiation area
  - Edge steepness
  - Effective average power/energy Density
- **Gaussian fits with:**
  - Correlation coefficient
  - Diameter
  - Centroid
  - Peak intensity
  - Fit roughness
- **Ellipticity at intensity slice:**
  - Major and minor axis diameter
  - Circularity (major/minor)
  - Axis orientation (rotation)
  - Auto align profiles to axis
- **Aperture analysis for circular, square, rectangular and elliptical beams:**
  - % power/energy in aperture
  - Uniformity in aperture
  - Aperture/diameter tracking
- **Selectable calculation area**
- **On-line statistical analysis (all results):**
  - Minimum, average, maximum
  - Sigma (standard deviation)
- **Pass/Fail test with fault action (all results):**
  - Ratio
  - Audio/visual alarms
  - Save/reject images
  - TTL pulse out
  - Stop data capture
- **Image averaging**
- **Peak energy/power density**
- **Relative energy/power**
- **Effective area**
- **Divergence at % energy/power**

Interactive Display Functions

- **On-line help**
- **Report generation:**
  - Report (.pdf)
  - BeamView window (screen capture)
- **Stored image paging**
- **Reference profile select**
- **Reference coordinate set**
- **Background subtraction**
- **Run/stop data analysis**
- **Control of cursors, profiles, aperture, position, rotation and size**
- **Live video on/off**
- **7 zoom levels**
- **Image and profile autoscale modes**
- **Auto peak/centroid locate**
- **“Hot” function keys**

BeamView Analyzer Software

BeamView Analyzer Software Features Summary

Image Capture and Storage

- **Pulsed or CW (continuous) analysis**
- **Multi-channel (not simultaneous) camera input**
- **Support for multiple camera types**
- **Adjustable camera exposure time**
- **RS-232 and TCP/IP communication protocols**
- **Multiple trigger modes:**
  - External trigger input
  - Autotrigger to a selected level
- **3 resolution modes with the LaserCam-HR and LaserCam-HR-UV cameras:**
  - 1280 x 1024 x 10
  - 640 x 512 x 10
  - 640 x 512 x 8
- **1 resolution mode with the LaserCam-HR-InGaAs camera:**
  - 320 x 256 x 14
- **Various capture modes:**
  - Continuous
  - Time interval
  - On command (keypress)
- **High-speed sample mode capture**
- **Profile storage**
- **Configuration storage with password protection**
- **Image data file formats in binary (bin), ASCII (img), bmp, jpg, png, tif**

Calibration Functions

- **Fully automatic background map correction (pixel-by-pixel) with bias offset**
- **Automatic background monitor and warning**
- **Optical scale factor (magnification/reduction)**
- **Far-field optic focal length**
- **Power/energy calibration factor**

Standard Graphics Feature

- **Contour map with profiles/aperture overlay:**
  - 3 plot types (contour/2D, 3D, Polar)
  - 4 scaling levels (fixed, scale-to-peak, low intensity, high intensity)
  - 4 style settings (gray, smooth, sharp, shaded bands)
- **Live video mode**
- **Calculation inclusion area display**
- **Profile/peak/centroid position cursor**
- **Graphic zoom**
- **Auto-scale 2D or profile intensity**
- **Polar beam wander plot**
- **On/off axis simultaneous display of:**
  - Position cursor
  - Cross-section profiles
  - Gaussian fit profiles
  - Reference profiles
  - Aperture overlay for:
    - Beam uniformity
    - % energy/power
- **Rotatable color 3D isometric plot**
  - 360°, 90° rotate/tilt
  - Hidden/transparent wire
  - Selectable wire density
  - Solid or single color
  - Auto-rotate mode

Beam Diagnostic Accessories

Laser-Grade Attenuation Optics for Cameras

Attenuation Optics and Accessories

Features

- **Laser-grade attenuation optics**
- **Compatible with all Coherent beam diagnostic cameras**
- **Virtually undistorted and interference-free attenuation**
- **Variable and fixed attenuation for beams up to 2000W/cm² or 50J/cm²**
- **C-Mount threads couple directly to cameras**

Most cameras are too sensitive for direct viewing of laser beams. For example, a typical diagnostics camera saturates at only ~0.5 µW/cm² power density (at ~633 nm) or at ~9 nJ/cm² (at 1064 nm) pulsed energy density. If the camera has an electronic shutter, it can be used for some CW beam attenuation, but there is more flexibility in using optical attenuation. Any attenuation optics introduced in the beam path must be manufactured to exacting specifications. The optics must be laser-grade substrate, and use the proper flatness and wedge to avoid etaloning and fringing, so that the beam is not distorted by the introduction of the attenuation. We offer attenuation optics that are designed to these specifications and packaged for use with our cameras.

Typical attenuations are 1:1 to 400,000:1, but even larger attenuations are possible. All Coherent diagnostic cameras accept C-Mount optics and accessories, and are delivered without a standard window in front of the sensor array. Such windows are liable to distort the optical beam. However, a LDFP (Low-Distortion Face Plate) filter is supplied with each camera purchased from Coherent. The LDFP is a laser-grade optic specified and polished for diagnostics use. It is mounted in a housing with C-Mount threads and provides attenuation of room light so that the camera can be used with the lights on. For operation below 400 nm, the LDFP must be removed.

The Continuously Variable Attenuator Modules (C-VARM and UV C-VARM) contain two wedge attenuators that are continuously variable and a step attenuator that allows attenuation from 10^7:1 down to 3000:1. The C-VARM and UV C-VARM can be finely adjusted to achieve both precise attenuation levels and maximum use of the camera's optical dynamic range.

The Variable Attenuator Module (VARM) is a triple-wheel filter holder that contains three filters per wheel. The filters are made to our exacting specifications for transmission value and material quality. The VARM is adjustable in attenuation in 64 discrete steps of approximately 16% reduction each time from 400,000:1 down to 1:1. The VARM can be easily returned to exactly the same attenuation level as previously used.

The BeamCUBE Fixed-Attenuator Modules (BCUBE and UV-BCUBE) provide fixed attenuation and beam pickoff for performing diagnostics on high power laser sources. The BCUBE and UV-BCUBE utilize the front surface reflection from an uncoated laser mirror to achieve beam samples at 2% to 10% of the incident radiation, depending upon beam polarization. Multiple BCUBEs can be coupled together for even higher fixed attenuation levels.

Beam Diagnostic Accessories

Attenuation Optics for Cameras

BCUBE, UV-BCUBE, VARM, C-VARM, UV C-VARM and all other Coherent cameras have female C-Mount threading, making them easy to connect with the male C-Mount connection flange provided with each attenuator. Also, all attenuators have 1/4-20 tapped holes for independent post or plate mounting.

The C-Mount flanges (threaded rings) also have a female RMS microscope thread. This allows a microscope objective to be coupled to the attenuators and extension barrels in order to create a flexible close-up imaging system for analysis of small/focused beams, fiber optics, laser diodes or LEDs.

VARM, LaserCam-HR-InGaAs, C-VARM, BCUBE, C-Mount Flanges and Barrel

Avoiding Multi-Filter Beam Distortion

The wavefront distortion through a number of optical filters can be calculated by taking the square root of the sum of the squares of the wavefront distortion of the individual components. For example, if the individual optics are made to λ/10 specifications and six are used, a total λ/4 RMS wavefront distortion will be introduced to the beam:

$$\sqrt{0.1^2 + 0.1^2 + 0.1^2 + 0.1^2 + 0.1^2 + 0.1^2} = 0.25$$

In general, a camera cannot sense less than ~λ/4 total distortion in the beam, so if a series of filters is used, they must be made to very exacting laser-grade specifications. Attenuating optics from Coherent are manufactured to better than a λ/10 surface specification, so at least six optics in series can be used. Calculate the Low-Distortion Face Plate (LDFP) and each BCUBE as one optic, and the VARM or C-VARM as three optics each.

Attenuator Selection

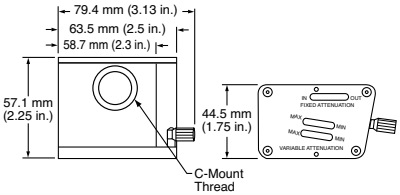
Attenuation is selected on the basis of power density in W/cm² or energy density in J/cm². The attenuation from the camera's Low-Distortion Face Plate (LDFP) will allow an average power density of up to 1.2 mW/cm². There are then only two more steps to attenuation selection:

1) Choose either the VARM or the C-VARM for up to 1W/cm².
2) In addition or alternatively, use a BCUBE beamsplitter module to pick off between 2% and 10% of the beam (depending on polarization and wavelength).

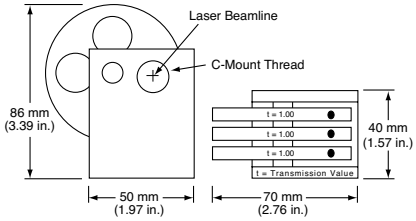
Device Specifications	Model	VARM	C-VARM	UV C-VARM	BCUBE	UV-BCUBE	BARREL SET (Barrels, 3 C-Mount Flanges)
**C24	Wavelength						
	Min. (nm)	380	380	190	380	190	–
	Max. (nm)	2200	2200	1100	2200	2200	–
	Attenuation						
	From	4×10^5:1	10^7:1	10^5:1	50:1	50:1	–
	To	1:1	3000:1	300:1	10:1	10:1	–
	Aperture (mm)	19	15	15	19	19	–
	Max. Power Density (W/cm²)	1*	1*	1*	2.0×10^9	2.0×10^9	–
	Max. Energy Density (J/cm²)	0.1*	0.1*	0.008	50	50	–
	Beam Offset (mm)	–	–	–	4.0	4.0	–
	Part Number	33-3328-000	33-3336-000**	33-6859-000**	1098403**	1098466	1098426

* The maximum power and energy density listed are the levels at which thermal lensing occurs.
** C24 Quick Ship program: eligible for next business day shipment.

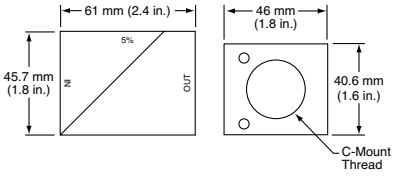
C-VARM and UV C-VARM



VARM



BCUBE and UV-BCUBE



Beam Diagnostic Accessories

Extreme-UV Beam Intensity Profiler (BIP) Optics

BIP-5000Z and BIP-12F attached to a LaserCam-HR

Features

- **UV operation from 10 nm to 355 nm**
- **Choice of 12 mm or 30 x 40 mm diameter apertures**
- **Operation with BeamView Analyzer Systems**

These Extreme-UV Beam Profiler Optics use UV-to-visible fluorescence converter face plates to couple the input laser beam to any appropriate Coherent camera. Any of our visible wavelength range cameras can be used with the Beam Intensity Profilers.

The Beam Intensity Profiler BIP-12F is a compact system accepting beams up to 12 mm in diameter from 10 nm to 355 nm. The front of the BIP-12F has a C-Mount thread, which allows it to be used in conjunction with the UV BeamCube when high power attenuation is needed for the spectral region 190 nm to 355 nm (see Laser-Grade Attenuation Optics for Cameras on page 105). The Beam Intensity Profiler BIP-5000Z has a zoom magnification range of 6:1 to 1:1 and accepts beams up to 30 mm by 40 mm from 10 nm to 320 nm. It comes with the mount shown.

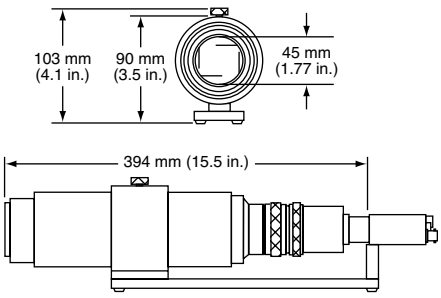
BIP-5000SPL Beamsplitter

When laser beam power or energy density exceeds recommended ranges, this beamsplitter provides additional high power attenuation capability for the BIP-5000Z. It provides a right-angle pick-off function and attaches to the entrance aperture of the BIP-5000Z.

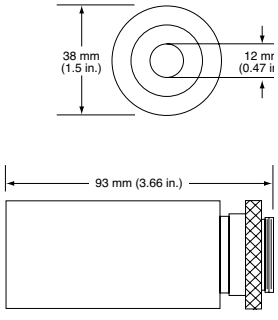
Device Specifications

Model	BIP-12F (2:1)	BIP-12F (1:1)	BIP-5000Z	BIP-5000SPL
Wavelength (nm)	10 to 355		10 to 320	10 to 320
Aperture (mm)	Ø12		30 x 40	Ø50
Resolution (camera-dependent)(µm)	20		70	–
Saturation				
at 193 to 248 nm	10 mJ/cm²		30 mJ/cm²	–
at 308 nm	50 mJ/cm²		50 mJ/cm2	–
Sensitivity	5 µJ/cm²		5 µJ/cm²	–
Damage Threshold				
CW	5W/cm²		1.5W/cm²	10W/cm²
Pulsed	500 mJ/cm²		600 mJ/cm²	50 J/cm²
Uniformity Over Aperture (%)	5			–
Image Persistence (fluorescence lifetime)	500 ns		5 µs	–
Image Magnification	2:1	1:1	6:1(Zoom) to 1:1	–
Part Number	33-3468-000	1053418	33-3484-000	33-3492-000

BIP-5000Z



BIP-12F



BeamMaster

Knife-Edge Beam Profiler

Features

- CW laser beam shape, power and position measurements
- Beam sizes from 3 µm to 9 mm with 0.1 µm resolution and high dynamic range
- Real-time Windows display, analysis and data logging system
- Wavelengths from 190 nm to 1800 nm
- USB interface
- Windows XP, Vista 32-bit, Vista 64-bit, Windows 7 32-bit, Windows 7 64-bit

BeamMaster is a high-precision, multiple knife-edge scanning laser beam profiler which can be configured to sample, measure and display cross-sectional profiles and/or 2D and 3D image plots in real time up to 5 Hz. Selectable averaging of 1 to 20 samples provides noise reduction and maximizes measurement accuracy. Data can be collected, displayed, stored and continuously streamed via USB. All screen images can be captured and stored, or printed.

BeamMaster can measure focused beam spots as small as 3 µm with 0.1 µm resolution and has an aperture as large as 9 mm with 1 µm resolution for larger beams. Measurements can be made from 190 nm to 1100 nm (Si-Enhanced) and from 800 nm to 1800 nm (InGaAs). Input powers can be as low as 10 µW. There is automatic gain control and two internal distortion-free optical attenuation filters are included (Si-Enhanced models)

Multiple Knife-Edges for Greater Resolution and Accuracy
BeamMaster is an advancement over the more common types of beam profilers, which use two orthogonal knife-edges or slits to scan the beam profile. The BeamMaster model BM-7 uses seven individual knife-edges on a rotating drum to scan the beam through seven different axes in a single rotation. This provides more accurate measurements of the true beam shape and dimensions by tomographically combining the data from all seven scans to reconstruct a profile of the beam. This technique also makes locating the angular orientation of elliptical beam major/minor axes much easier than searching by rotating the sensor head around the optical beam axis. For applications with circular or near-Gaussian beams, the lower-cost BM-3, with only three knife-edges, is also available.