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Measurement of Laser Beam Profile and Propagation Characteristics

1. Laser Beam Measurement Capabilities

Laser beam profiling plays an important role in such applications as laser welding, laser focusing, and laser free-space communications. In these applications, laser profiling enables to capture the data needed to evaluate the change in the beam width and determine the details of the instantaneous beam shape, allowing manufacturers to evaluate the position of hot spots in the center of the beam and the changes in the beam's shape.

Digital wavefront cameras (DWC) with software can be used for measuring laser beam propagation parameters and wavefronts in pulsed and continuous modes, for lasers operating at visible to far-infrared wavelengths:
- beam propagation ratio M^2;
- width of the laser beam at waist w_0;
- laser beam divergence angle θ_x, θ_y;
- waist location $z\text{-}z_0$;
- Rayleigh range z_{Rx}, z_{Ry};
- Ellipticity;
- PSF;
- Wavefront;
- Zernike aberration modes.

These parameters allow:
- controlling power density of your laser;
- controlling beam size, shape, uniformity, focus point and divergence;
- aligning delivery optics;
- aligning laser devices to lenses;
- tuning laser amplifiers.

Accurate knowledge of these parameters can strongly affect the laser performance for your application, as they highlight problems in laser beams and what corrections need to be taken to get it right.

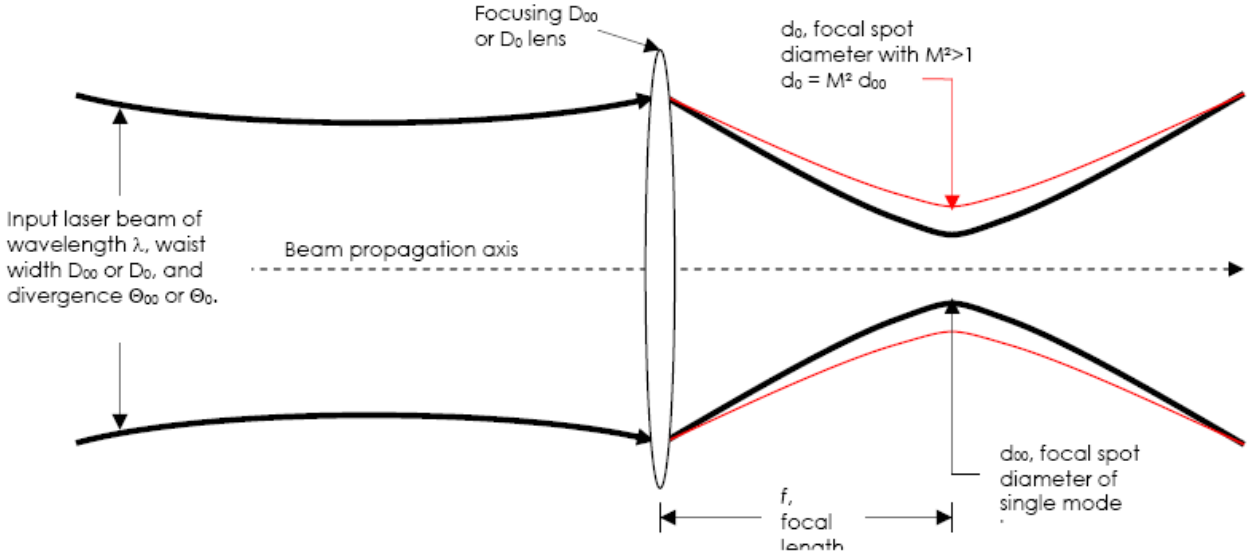


Figure 1. Characteristics of a laser beam as it passes through a focusing lens.

2. Beam Propagation Parameters

M², or Beam Propagation Ratio, is a value that indicates how close a laser beam is to being a single mode TEM_{00} beam. This in turn relates to how small a spot a laser can be focused. For a laser beam propagating through space, the equation for the divergence, Θ, of a pure Gaussian TEM_{00} unfocused beam is given by:

$$\Theta_{00} = 4\lambda / \pi D_{00} \quad (1)$$

where D_{00} is the waist diameter of the beam, and λ is the wavelength. Actual beams with additional modes often start with a larger beam waist, D_0, and/or have a faster divergence Θ_0. In this case Equation (1) becomes:

$$\Theta_0 = M^2 4\lambda / \pi D_0 \quad (2)$$

where Θ_0 and D_0 are the divergence and width of a higher mode beam and M² is greater than 1 and is named the "Beam Propagation Ratio" per the ISO 11146 standard. When a pure Gaussian laser beam is focused, the diameter of the focused spot is defined by:

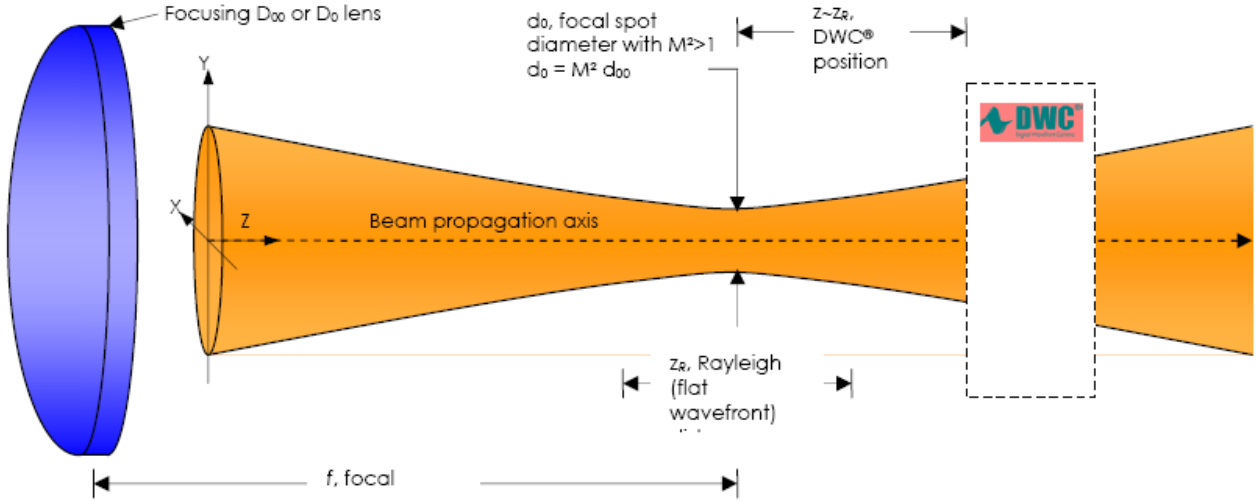
$$d_{00} = 4\lambda f / \pi D_{00} \quad (3)$$

where D_{00} is the ideal focused spot diameter, f is the focal length of the lens, and is placed one focal length from the lens as shown in the Figure 1. However, when a distorted or multimode beam is focused, Equation (3) becomes:

$$d_0 = M^2 4\lambda f / \pi D_0 \quad (4)$$

Apart from M², the measured beam propagation parameters characterizing laser beams are:

$w_0 = d_0/2$– the waist radius in X (horizontal) and Y (vertical) directions;
$z\text{-}z_0$ – the distance between measurement and waist planes;
z_R – the Rayleigh range, for which the radius of curvature R of the wavefront is minimal;
θ – the divergence angle of the measured laser beam far from the waist;
R – the radius of curvature of the wavefront in the measurement plane.



3. Measurement of Propagation Parameters with DWC

3.1 Principle

Propagation parameters are measured by DWC on real beams by focusing the beam with a fixed position lens of known focal length, and then measuring the characteristics of the artificially created beam waist and divergence.

Measurement of the beam propagation parameters with DWC is based on the simultaneous measurement of the high-resolution images of intensity and wavefront. The wavefront is computed starting from two slightly defocused beam intensity images acquired on one CCD camera inside DWC by mathematical computations involving the two images and the difference between them (Figure 2). From the wavefront, the beam propagation parameters are obtained by straightforward but tedious computations.

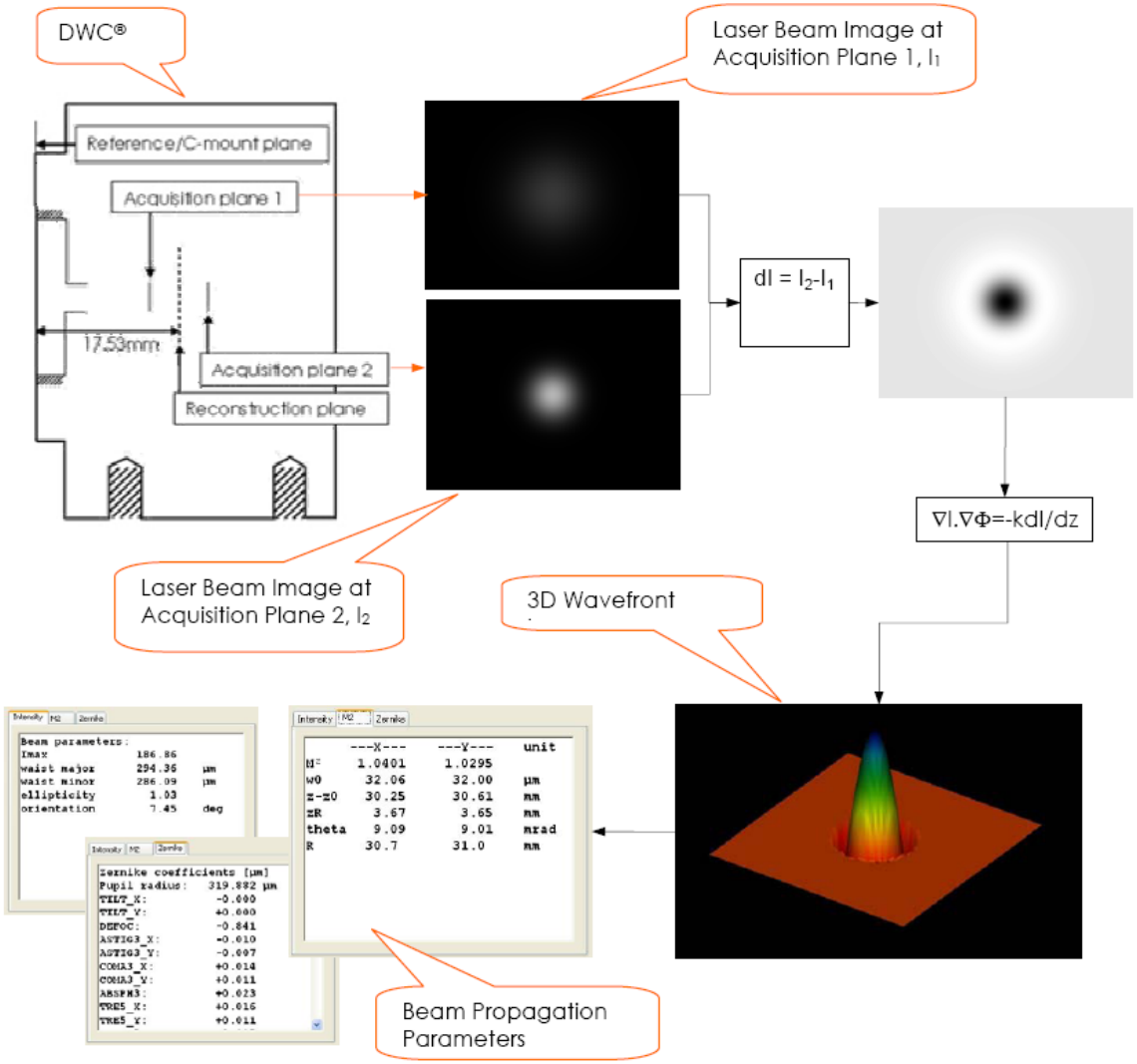


Figure 2. Principle of DWC: Acquisition of two images in real time at two different focal planes, wavefront extraction and computation of beam propagation parameters.

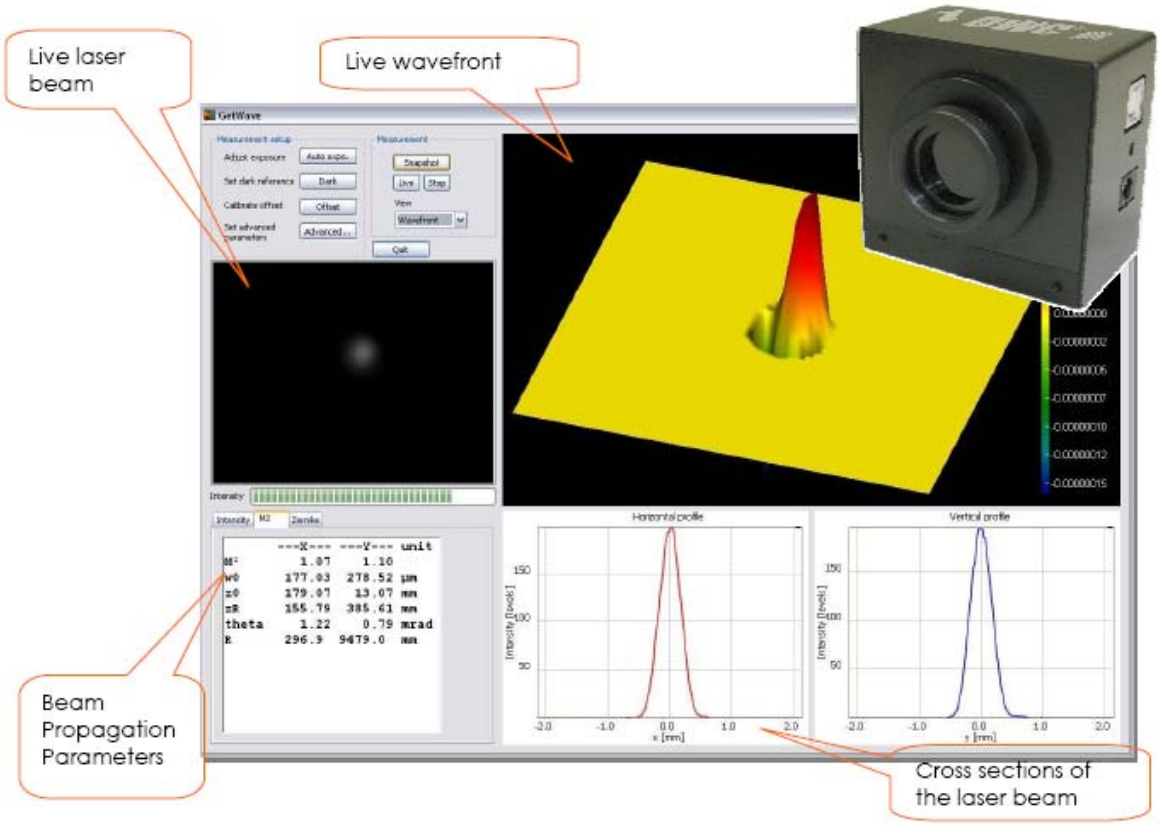


Figure 3. DWC and the Graphic User Interface of its associated software.

3.2 System Set-up

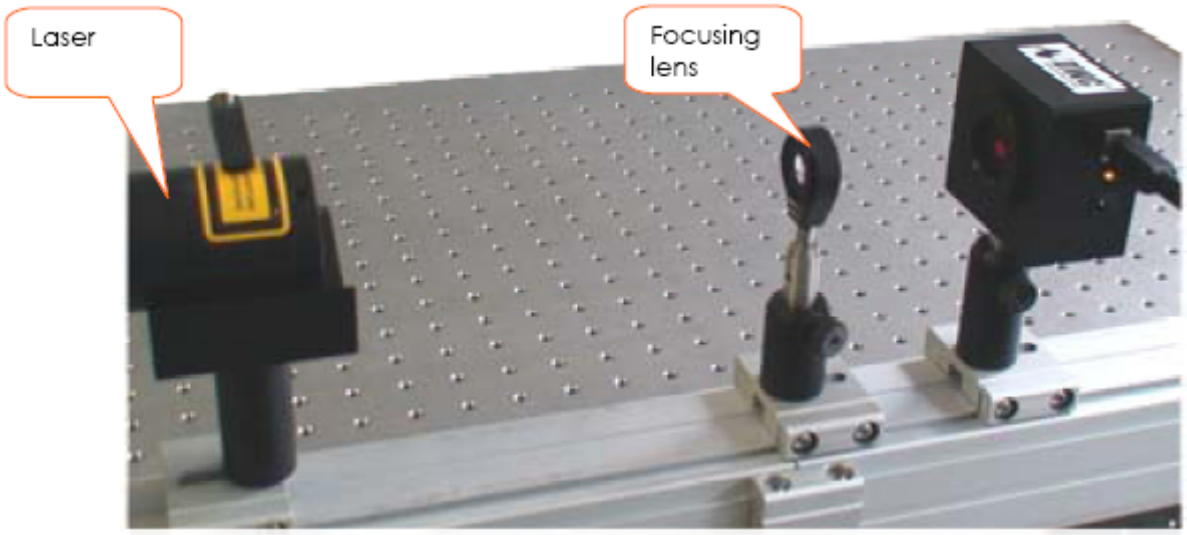
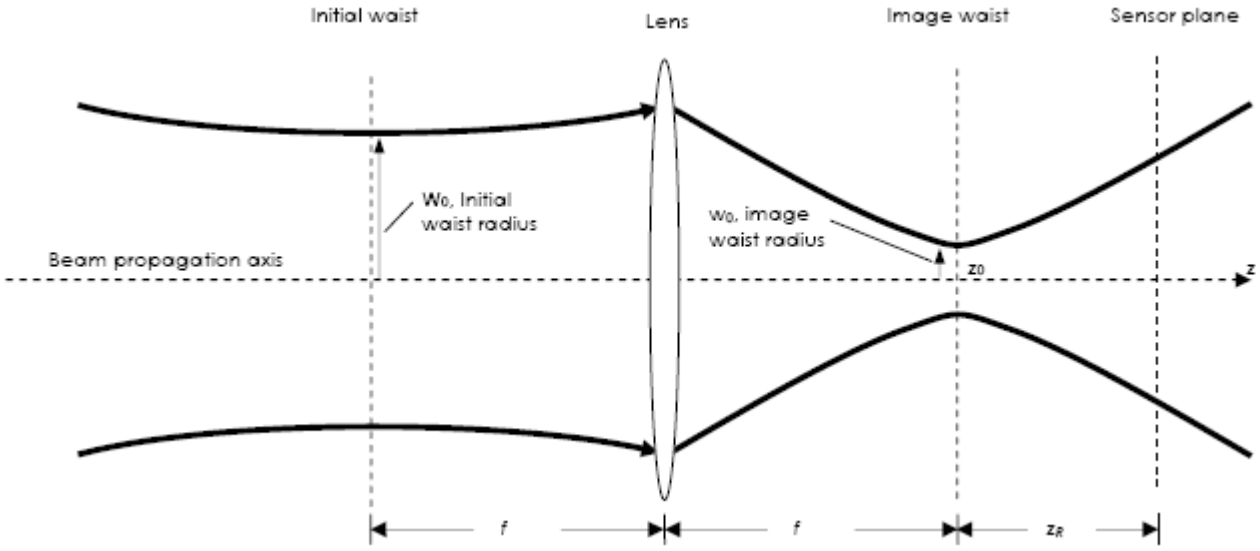


Figure 4. Example of a setup for measurement of laser propagation parameters with DWC.



STPV Series All-in-One Laser Beam Analyzers

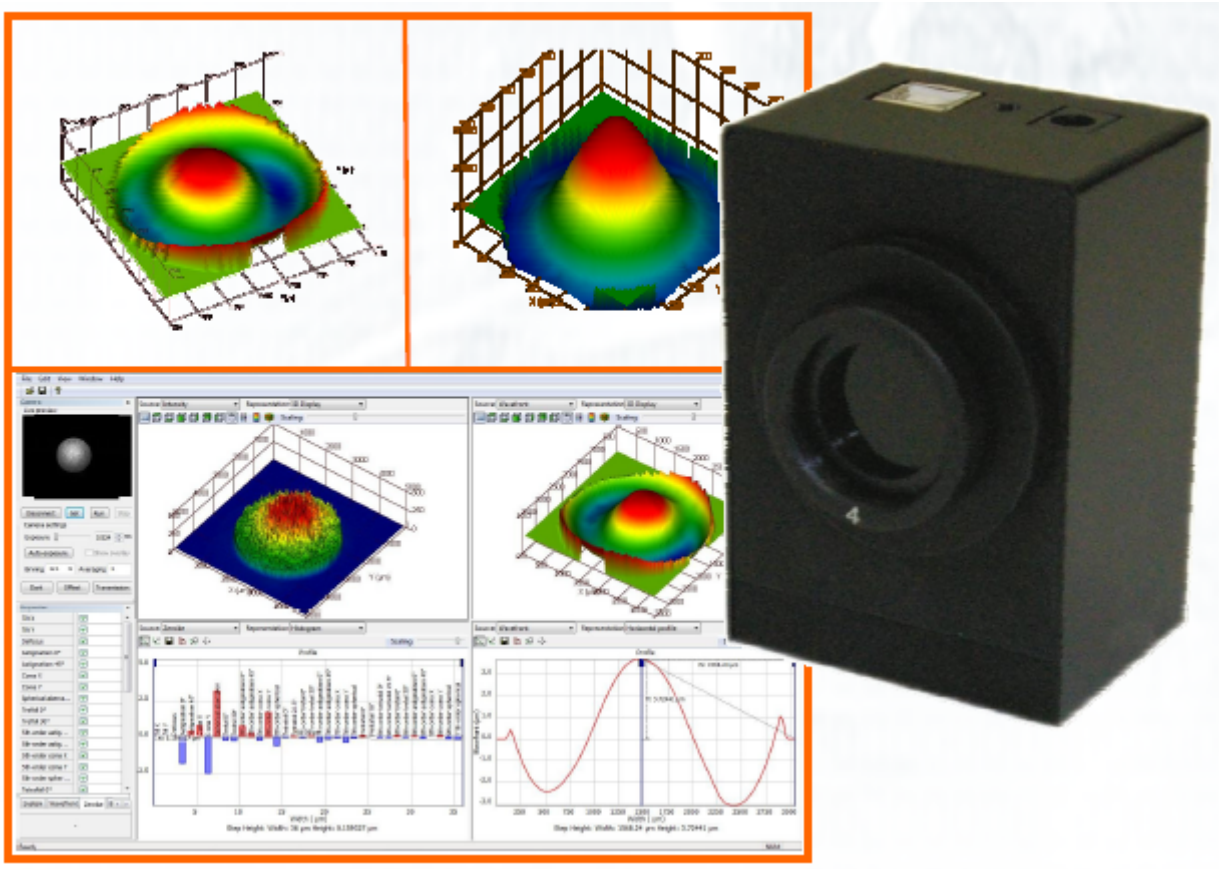
High Resolution CCD Beam Profiler
Instant Beam Propagation & Wavefront Analysis
One Shot M^2 Measurement

The smart all-in-one compact DWC beam profiler performs beam propagation analysis in one shot.

Thanks to its capability to measure simultaneously intensity and phase data at ultra high resolution, beam shape and intensity distribution can be measured at any distance from its original location without moving parts. All critical parameters for laser beam monitoring such as energy distribution and beam propagation parameters can be measured without need of purchasing additional tools.

DWC combined with laser beam measurement software provides comprehensive one-shot measurements of the laser beam: beam propagation parameters such as M^2, divergence, tilt, energy characteristics in any XY plane.

Users can make necessary adjustments in real time by visualizing the beam along the Z propagation axis, graph of waist, 2D/3D intensity profiles can be easily extracted by selecting a Z position with a slider.



Typical Applications

1. Laser Beam & Wavefront Profiling

Featuring resolution of 250 000 measurement points, high dynamic range (± 1500 λ of wave tilt at 633 nm), and real time wavefront analysis at 25Hz video frame rate, DWC is an ideal tool for laser beam analysis.

Multiple views of the reconstructed high resolution wavefront, containing 3D plot, wavefront gradient, fringes display are output in real time.

For laser beam measurement, the technique uses Digital Wavefront Sensor to obtain high-resolution intensity and wavefront images of the propagating beam at one location on a 1M pixel CCD array

camera. From the one-shot intensity and phase measurements and numeric propagation the laser beam is obtained at >10 positions. The instrument is suitable for measurement of both CW and pulsed lasers down to single-shot rates, and provides quantitative measurement of numerous beam spatial characteristics in accordance with the ISO 13694 standard and M^2 parameters according to the ISO 11146 standard. Beam diameters are obtained with accuracy to better than 2% that translates to M^2 measurements with accuracy to better than 4%.

2. Beam Propagation Analysis

DWC is a one shot device offering detailed beam propagation analysis in a range up to several Rayleigh distances in the beam propagation direction.

Without displacing the device, the beam's energy - related characteristics such as beam celtroid and peak locations, and peak fluences can be precisely and quickly computed by purely numerical procedures, in a desired number of planes around the position of DWC.

The quality of the laser beam and the visualization of its hot spots can be monitored with no operator intervention over large distances around the laser beam waist.

3. Beam shaping & beam monitoring

DWC can be used for precise beam monitoring & beam shaping - both in intensity and in phase - made e.g. by phase spatial light modulators (SLM's), deformable mirrors (DM's) and other beam shaping and beam forming devices.

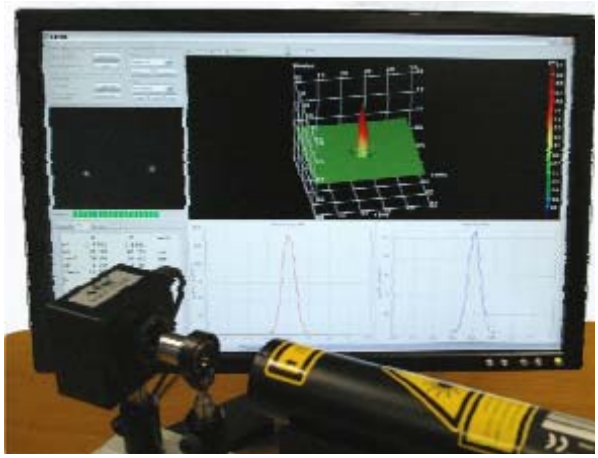
DWC is used e.g. to control of the adjustment of beam shaping modules to generate round and square top hat focal spots, offering ultimate resolution, speed and dynamic range.

Key Advantages

- Wavefront sensor, beam propagation parameters & power measurement in one device
- High spatial resolution for both intensity and wavefront measurements
- One shot M² measurement without additional accessories or moving parts
- Instant beam propagation analysis, power measurement in any plane
- Laser beam monitoring with real time display of intensity, wavefront, PSF
- Compact & light beam profiler for pulsed & CW lasers
- Custom solutions for UV, NIR & FIR wavelength range

Measurement Capabilities

- Beam M²
- Propagation parameters
- Beam energy parameters in any plane
- Beam Wavefront Measurement
- CW & Pulsed Lasers



Parameters

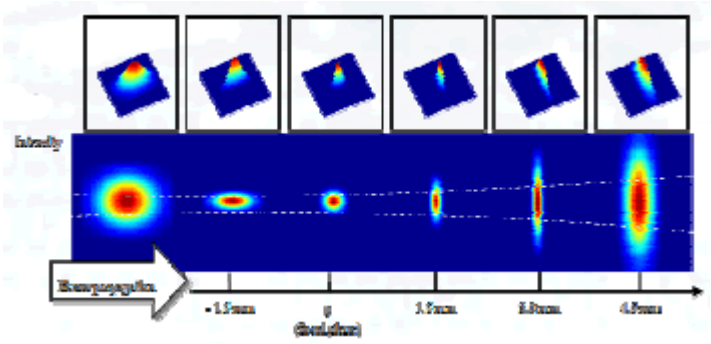
- Entrance aperture: 5.9 x 3.1 mm
- Z separation: 17.5 mm
- Measurement points: 500 x 500
- Absolute accuracy: <0.01λ
- Sensitivity: <0.005λ
- Repeatability: <0.01λ rms
- Dynamic range: 500λ
- Acquisition rate: 15 Hz max (processor dependent)
- M2 accuracy: ±5%
- M2 repeatability <2%
- λ range: 350 - 1100 nm (Silicon CCD) <350 & >1100 nm with other cameras
- Dimensions (mm): 25 L x 32 W x 43 H; Weight0.350kg.

Software Functions

GUI software XP, Vista and Windows 7 compatible, performs intensity and wavefront acquisition in a remarkably fast and easy way and provides comprehensive tools for beam profiling including intensity distribution and beam propagation parameters.

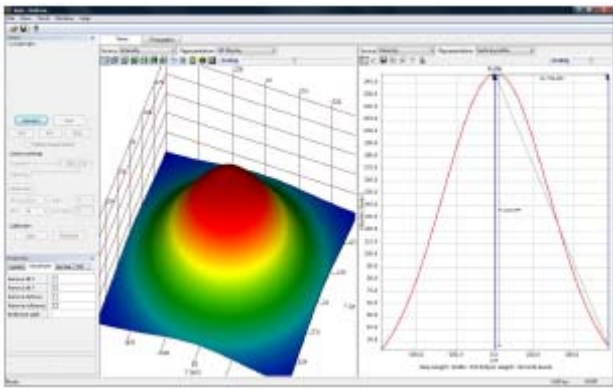
1. Acquisition & Display
- Automatic calibration & acquisition
- Live display 2D and 3D intensity, wavefront, PSF Single and continuous acquisition

2. Analysis



Beam intensity parameters:
- Maximum intensity levels
- Ellipticity of the beam spot
- Beam spot major and minor axis dimensions

Beam propagation parameters:
- M2 parameter for the X and Y directions
- Waist size in X and Y directions
- Distance between sensor position and waist planes
- Rayleigh range
- Divergence angle of the beam
- PSF, Strehl ratio
- Real-time Zernike display and analysis
- Profiles of wavefront and intensity



3. Export & Report
-- Wavefront and Zernike data Report Editor, HTML Compatible Presentation

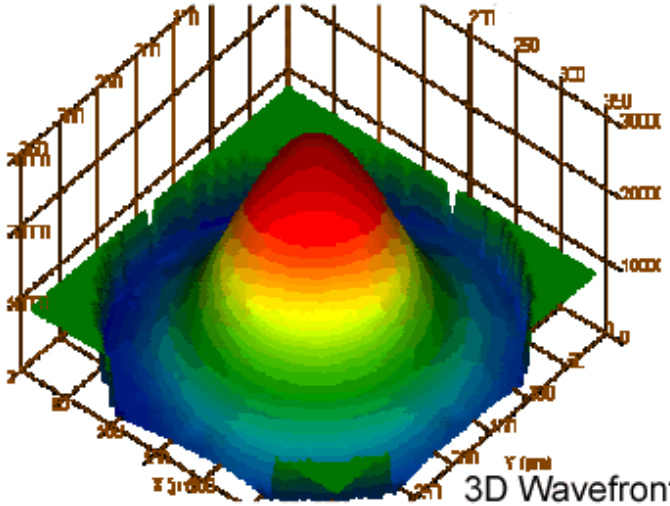
Order Information
STPV all-in-one beam analyzer, including
1. Hardware:
CCD Beam Profiler: CCD 2/3", 1392x1040, 6.45µm square pixels, dynamic range 66dB, frame rate 15 fps, pixel depth 12 bits;
  • Wavelength 350 – 1100 nm;
  • Real time & simultaneous acquisition of laser beam intensity & phase with 500 x 500 measurement points;
  • Maximum beam size 3.2mm x 3.2mm;
  • USB2 cable 2m computer interface
  • C-mount optics interface;
2. Software
XP/Vista/Windows7 compatible, providing:
  • One shot M² measurement and intensity profiles at each plane along propagation axis;
  • Single and continuous measurement: acquisition, process and display;
  • Auto trigger, pulsed and CW laser modes;
  • Display of 2D & 3D intensity and Display of 2D & 3D wavefront;
  • Complete beam propagation analysis in planes in a range of distances from the waist.
Beam intensity parameters:
  • Maximum intensity levels in the acquired image;
  • Beam spot major axis dimension in the acquisition plane;
  • Beam spot minor axis dimension in the acquisition plane;
  • Ellipticity of the beam spot;
  • Orientation of the ellipse major axis as compared to the trigonometric base.
Beam propagation parameters:
  • M² parameter for the X and Y directions;
  • 4σ Waist size in X and Y directions;
  • Distance between the measurement and waist planes;
  • Rayleigh range;
  • Divergence angle of the beam;
  • Beam's wavefront radius of curvature.
Beam wavefront parameters:
  • Zernike display: coefficient values.
Export data: intensity profiles.

STPV2 Series All-in-One Laser Beam Profiler

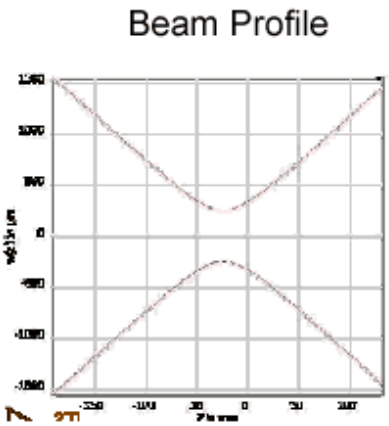
Cheapest Beam Profiler
Instant Beam & Wavefront Analysis

STPV2 is a smart and cost effective wavefront sensor for dynamic analysis of wavefront shape and intensity distribution of laser sources or wavefront distortion induced by optical components.

- Plug & Play USB wavefront sensor
- Wavefront map 500 x 500 data points
- No Lenslets, no trade-off between dynamic and resolution



3D Wavefront Map



Real Time Beam Monitoring
- Simultaneous measurement of phase and intensity
- High Resolution Wavefront map
- Zernike analysis with live histogram

Laser Beam Analysis with no moving parts
- Instant beam intensity distribution at any plane

Beam Monitoring & Analysis
STPV2 includes GUI software XP, Vista, Windows 7 compatible. User interface provides comprehensive tools for wavefront & intensity acquisition, display, measurement and analysis.

Applications
- High precision beam profiling
- Beam monitoring & shaping with spatial light modulators
- Wavefront analysis in complex optical setup
- LOAs & HOAs measurement
- Laser beam quality
- Adaptive optics

Hardware Specifications & Performance

Measurement points	500 x 500
Maximum Beam Dimensions	3.3 x 3.3 mm
Camera Resolution	1280 x 1024
Pixel Size	6.7 x 6.7 µm
Pixel Bit Depth	8 bits
Wavelength	350 – 1100 nm
Wavefront Sensitivity	λ/100 rms (@ 633 nm)
Wavefront Accuracy	λ/50 rms (@ 633 nm)
Wavefront Dynamic	> 1 500 λ (@ 633 nm)
Optical Input Connector	C-Mount
Power Supply	Via US
Weight & Size	350g, 25 x 32 x 43mm

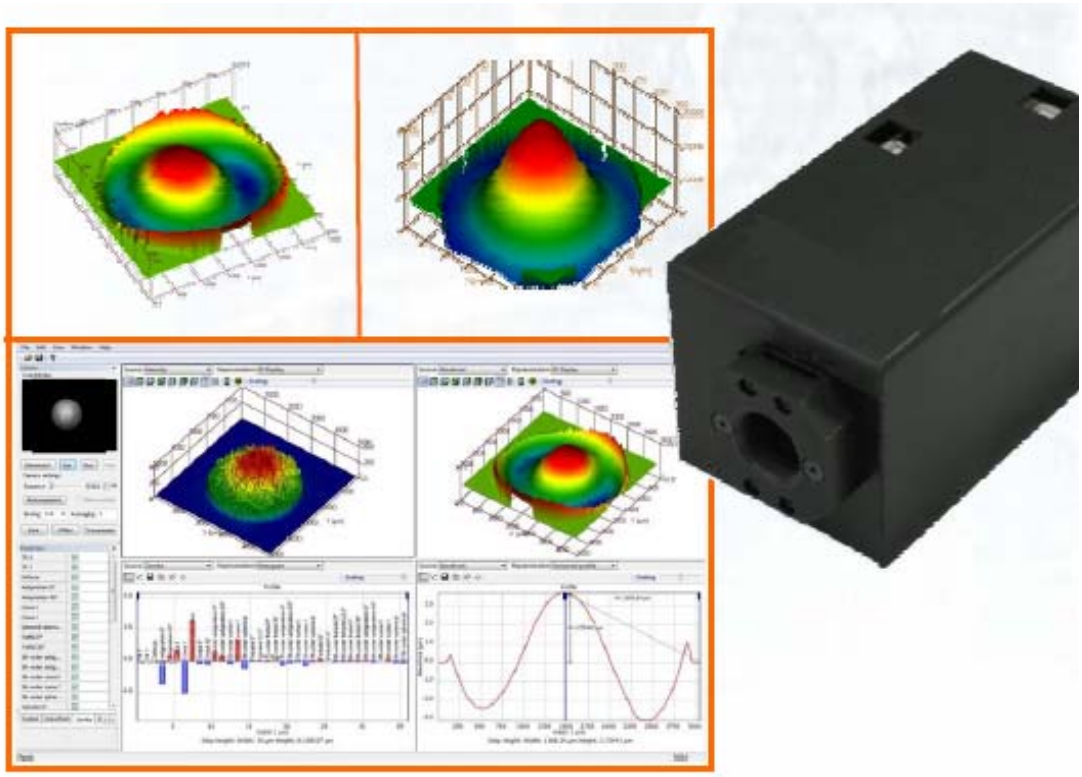
Main Difference between STPV and STPV2

STPV is based on a CCD chip 12 bits dynamic range, software includes Intensity distribution, Wavefront Analysis (Zernike) and Beam propagation analysis.

STPV2 is based on CMOS chip with 8 bits dynamic range, software includes intensity distribution & wavefront analysis but without Beam propagation analysis.

STPV3 series Large Aperture Beam Profiler

High Resolution CCD Beam Profiler
Instant Beam Propagation & Wavefront Analysis
One Shot M2 Measurement



A Smart and Affordable Beam Profiling Solution
Large Beams up to 20 mm
Wavefront Measurement Points 2000 x 2000
Wavefront XY Resolution 9 µm
Large Aperture Beam Profiler
High Resolution CCD Beam Profiler
Instant Beam Propagation & Wavefront Analysis
One Shot M2 Measurement

Take advantage of the latest advances in wavefront sensing. The compact and light Profiler delivers all critical beam profiling parameters in one single device.

All-In-One BEAM PROFILER

With no moving parts or additional accessories, Digital Wavefront Camera (DWC) beam profiler performs all critical laser beam measurements including intensity distribution, wavefront and beam propagation analysis.

High Resolution Beam Profiling Real Time Wavefront Measurement

On Click Beam Propagation Analysis:

Intensity distribution • XY Profile • Centroid • Divergence angle • Asymmetry

DWC is a reliable CCD beam profiler for pulse & CW laser offering high dynamic and resolution for accurate intensity analysis.

Real Time Wavefront Measurement:

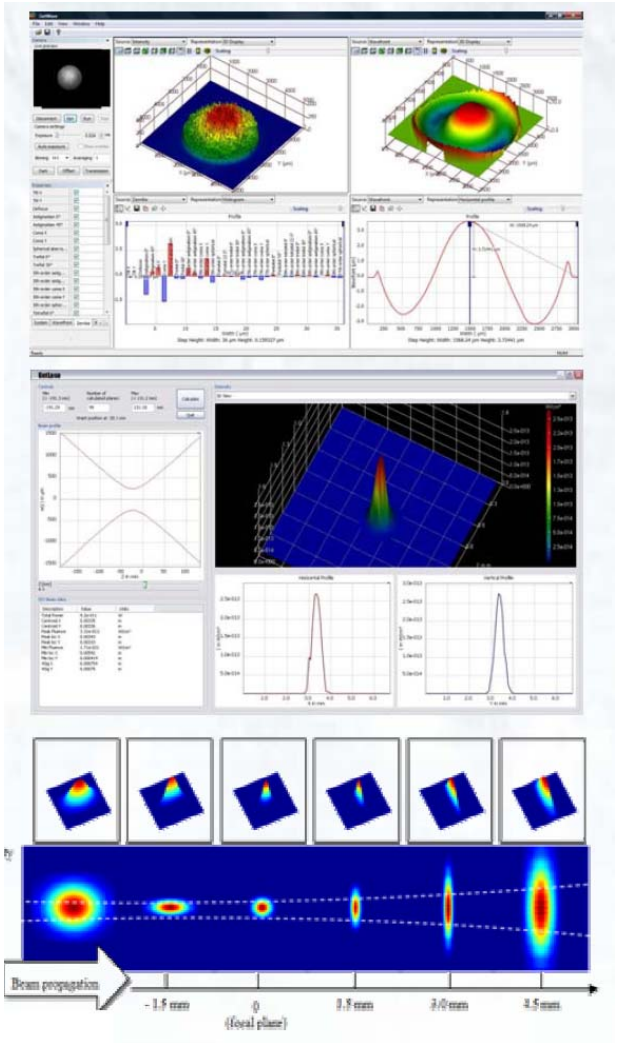
Zernike Analysi • Low and high Order Aberrations • Astigmatism

DWC provides high resolution wavefront data, these useful parameters allows laser beam analysis in its all dimensions.

On Click Beam Propagation Analysis:

One Shot M² • Intensity distribution at any selected plane • Divergence angle • Rayleigh Range

It has capability to measure phase and intensity simultaneously. DWC delivers beam propagation analysis, thus providing an instant picture of laser beam behavior along the propagation axis.



Wavefront Measurement Points	2000 x 2000
Maximum Beam Dimensions	20 x 20 mm
Camera Resolution	3648 x 2670
Pixel Size	9 x9 um
Pixel Bit Depth	12
Wavelength	350 – 1100 nm
Wavefront Sensitivity	3nm, >λ/200 rms (@ 633 nm)
Wavefront Accuracy	6nm, >λ/200 rms (@ 633 nm)
Wavefront Dynamic	950um, 1500λ (@ 633 nm)
Camera Interface	USB 2.0
Dimensions	83 W x 76 H x 141 L mm
Weight	870 grams

VIS/NIR Beam Profiler: STCam CCD

Our CCD is developed to provide excellent sensitivity from the VIS to NIR spectral range. Thanks to its high resolution and its small pixel size, the STCam is a high performance tool for laser beam analysis of continuous wave (CW) and pulsed laser modes. Due to its high dynamic range the STCam captures even higher laser modes with outstanding detail.

The passive cooled sensor of the STCam is constructed without cover glass to avoid interference patterns. For sensor protection a low distortion neutral density filter is integrated. The STCam supports the ultra-fast FireWire IEEE 1394b interface with data transfer rates up to 800 Mbit/s. The plug and play design facilitates easy and flexible integration and operation.

The portable STCam is designed to be used in a variety of applications in industry, science, research and development, including:

- Laser beam analysis of CW and pulsed lasers,
- Quick control of laser modes and adjustment errors,
- Test equipment for scientific research,
- Near-Field and Far-Field analyses of lasers, LED devices and other light sources.

The enhancement of product quality, process reliability and efficiency are just a few of the many benefits of our unique beam profiler cameras. The STCam includes the specifically designed analysis software, STRayCi, which supports Windows XP/Vista operating systems. Its sophisticated software architecture opens up new opportunities in laser beam analysis according to ISO standards.

The concept of the STCam enables easy adaption to standard optical imaging systems, attenuators and opto-mechanical components ensuring highest flexibility. This includes:

- Microscope lens and beam expander,
- UV-Converter and IR-Converter,
- Fixed and variable attenuators, etc.

ACCESSORIES

Neutral Density Filter: To expand the power range of the STCam several absorptive and metallic-coated neutral density filters are available, which are specified by optical densities ranging from OD 1.0 to OD 4.0.

FireWire Component: We offer different FireWire PCI / PCI Express cards for installation direct into the PC. Standard FireWire cables are suitable for industrial applications and are available in various lengths.

Trigger Device: To synchronize the STCam with pulsed laser systems, our trigger device is perfectly suited. This frequency and delay generator is software controllable and enables the synchronization of up to four beam profilers with different delay times simultaneously.

	CCD-1201	CCD-1301	CCD-2301	CCD-2302
SENSOR DATA				
Format	1/2”	1/3”	2/3”	2/3”
Active area	6.5x4.8mm	4.8x3.6mm	9.0x6.7mm	8.5x7.1mm
Number of pixel	1388x1038 (1.4MPixel)	1292x964 (1.2MPixel)	1388x1038 (1.4MPixel)	2452x2056 (5MPixel)
Pixel size	4.65x4.65µm	3.75x3.75µm	6.45x6.45µm	3.45x3.45µm
Spectral response without cover	350-1100nm	350-1100nm	350-1100nm	350-1100nm

glass				
Laser beam diameter min/max	46.5/4mm	37.5/3mm	64.5µm/5mm	34.5µm/5.5mm
Sensor cooling	passive	passive	passive	passive
CAMERA FEATURES				
Lens Mount	C-Mount	C-Mount	C-Mount	C-Mount
Bit depth (output)	14Bit	14Bit	14Bit	14Bit
Dynamic (signal to noise)	60dB (1:1000)	59dB (1:900)	67dB (1:2200)	54dB (1:500)
Frame rate	up to 15Hz	up to 30Hz	up to 16Hz	up to 9Hz
Exposure time	100µs-1s	100µs-1s	100µs-1s	100µs-1s
Interface	FireWire (IEEE1394b)	FireWire (IEEE1394b)	FireWire (IEEE1394b)	FireWire (IEEE1394b)
I / O connector	12-Pin Hirose	12-Pin Hirose	12-Pin Hirose	12-Pin Hirose
Mode	CW or pulsed	CW or pulsed	CW or pulsed	CW or pulsed
Trigger	TTL-signal	TTL-signal	TTL-signal	TTL-signal
Combinable with	IR-/UV-Converter Beam expander Attenuator	Microscope lens Beam expander Attenuator	Beam expander Attenuator	Beam expander Attenuator
SPECIFICATIONS				
Mechanical dimensions (WxHxL)	60x60x103.8mm	60x60x103.8mm	60x60x103.8mm	60x60x103.8mm
Weight	300g	300g	300g	300g
Electrical requirements	DC 8V-36V	DC 8V-36V	DC 8V-36V	DC 8V-36V
Storage temperature*	-10°C…+60°C	-10°C…+60°C	-10°C…+60°C	-10°C…+60°C
Operating temperature*	+5°C…+45°C	+5°C…+45°C	+5°C…+45°C	+5°C…+45°C
Regulations	CE, RoHS	CE, RoHS	CE, RoHS	CE, RoHS

* without condensation

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Neutral Density Filter

Our neutral density filters allow broadband attenuation for a spectral range from VIS to NIR. Due to their excellent surface quality the absorptive and reflective filters enable precise beam attenuation for low power applications. The level of attenuation is specified by the optical density. Filters with different optical densities can be combined. A filter adapter is available to mount the filters on the STCam aperture.

Reflective ND filter		Absorptive ND filter
NDR-10 / NDR-20 / NDR-30 / NDR-40		NDA-10 / NDA-20 / NDA-30 / NDA-40
Optical density*	1.0 / 2.0 / 3.0 / 4.0	1.0 / 2.0 / 3.0 / 4.0
Spectral range	200nm - 1200nm	400nm - 700nm / 700nm - 1200nm
Material	UV-Fused silica (Coating: Metal)	Schott glass
Flatness	1λ @ 300nm	λ/10 @ 632.8nm
Scratch-Dig	40 - 20	40 - 20
Parallelism:	3arcmin	10arcsec
Optical density tolerance	±5%	±5%
Power (Pmax)	< 1W	< 1W
Intensity (Imax)	0.75W/cm2	1W/cm2
Diameter	□=25mm/25.4mm	□=25mm/25.4mm
Operating temperature	< 100°C	< 100°C
Filter threads	Filter thread / Filter mount	Filter thread / Filter mount
Filter adapter	C-Mount thread / Filter thread	C-Mount thread / Filter thread

CO2 Laser Beam Profiler

The high performance STCL system is based on industry's unique imaging technique. It is designed for monitoring high-power CO2 lasers in best performance. Thanks to its high resolution and its incomparable real-time capabilities, this highly efficient beam profiler is optimized for laser beam analysis of continuous wave (CW) and pulsed laser systems. The STCL system ensures beam profiling:

- By high frame rates and high resolution,
- Without optical components in the beam path,
- Without scanning techniques, fluorescent materials or toxic fumes through acrylic mode burns.

The STCL supports the ultra-fast FireWire IEEE 1394a/b interface with data transfer rates up to 800 Mbit/s. The plug and play design facilitates easy and flexible integration and operation.

The compact and portable STCL is designed to be used in a variety of applications in industry, science, research and development, including:

- Laser beam analysis of CW and pulsed lasers,
- Quick control of laser modes and adjustment errors,
- Test equipment for scientific research,
- Near-Field and Far-Field analyses of lasers.

The enhancement of product quality, process reliability and efficiency are just a few of the many benefits of our unique beam profiling system.

The STCL system includes the specifically designed analysis software, STRayCi, which supports Windows XP/Vista operating systems. Its sophisticated software architecture opens up new opportunities in laser beam analysis according to ISO standards.

ACCESSORIES:

Attenuation Units: The water-cooled attenuation units are based on zinc selenide (ZnSe) and are designed for a 10° / 45° angle of incidence. Due to its excellent performance the unit can be used up to laser powers of 3kW and intensities of 5kW/cm2.

FireWire Components: We offer different FireWire PCI/PCI Express cards for installation direct into the PC. Standard FireWire cables are suitable for industrial applications and are available in various lengths.

Trigger Device: To synchronize the STCL system with pulsed laser systems, our trigger device is perfectly suited. This frequency and delay generator is software controllable and enables the synchronization of up to four beam profilers with different delay times simultaneously.

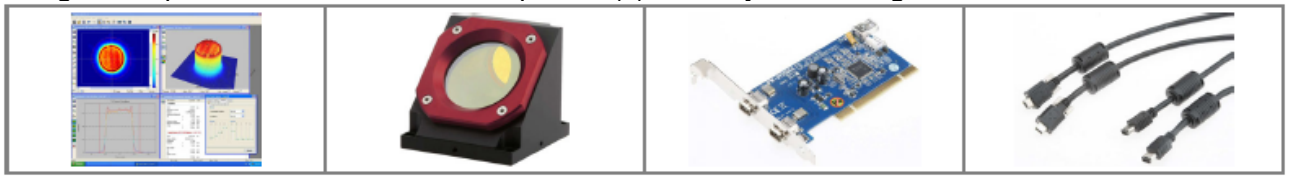
Technical Specifications:

	STCL200	STCL500	STCL500
IMAGE CONVERTER			
Spectral sensitivity:	optimized for 10.6µ m	optimized for 10.6µ m	optimized for 10.6µ m
Clear aperture:	20mm	30mm	30mm
Laser beam diameter (1/e2):	1mm - 10mm	2mm - 15mm	2mm - 15mm
Intensity range* :	20W/cm2 - 2.000W/cm2	20W/cm2 - 2.000W/cm2	20W/cm2 - 2.000W/cm2
Input power (max):	200W (250W, 30s)	500W (550W, 30s)	500W (550W, 30s)
With attenuation unit 0°:	up to 2kW	up to 2kW	up to 2kW

With attenuation unit 90°:	up to 2.5kW	up to 3kW	up to 3kW
Effective pixel size:	x=39µm / y=36µm	x=55µm / y=51µm	x=30µm / y=29µm
Effective pixel size with 2x binning:	x=78µm / y=73µm	x=110µ m / y=102µ m	x=60m / y=58µm
CAMERA FEATURES*			
Sensor:	CCD	CCD	CCD
Resolution (with 2x binning):	752 x 580pixel (367 x 288pixel)	752 x 580pixel (367 x 288pixel)	1384 x 1038pixel (688 x 518pixel)
Frame rate (with 2x binning):	up to 25Hz (up to 50Hz)	up to 25Hz (up to 50Hz)	up to 15Hz (up to 25Hz)
Interface:	FireWire (IEEE1394a)	FireWire (IEEE1394a)	FireWire (IEEE1394b)
Mode:	CW or pulsed	CW or pulsed	CW or pulsed
SPECIFICATIONS			
Mechanical dimensions (WxHxL):	298x141x76mm	340x165x92mm	340x165x92mm
Weight:	2.6kg	3.3kg	3.4kg
Electrical requirements:	AC120V/240V; 48 - 63Hz; 320W	AC120V/240V; 48 - 63Hz; 570W	AC120V/240V; 48 - 63Hz; 570W
Storage temperature** :	0°C…+60°C	0°C…+60°C	0°C…+60°C
Operating temperature** :	+5°C…+35°C	+5°C…+35°C	+5°C…+35°C
Humidity:	20%...80%	20%...80%	20%...80%
Regulations:	CE, RoHs	CE, RoHs	CE, RoHs

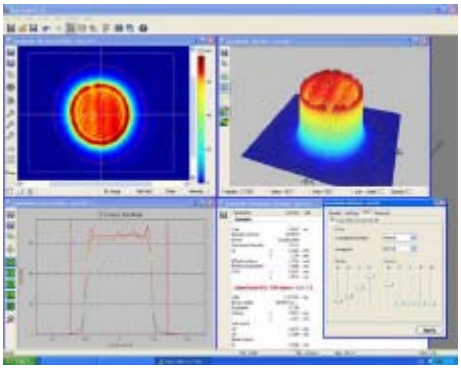
* different parameters on request
** without condensation

Design and specification of the described product(s) are subject to change without notice.



Laser Beam Profiling Software STRayCi

Our sophisticated beam profilers are available with the specifically designed analysis software, STRayCi, which supports Windows XP/Vista operating systems. It is available as 32 Bit / 64 Bit version and can control up to eight beam profiler cameras on a single computer.



Due to its clearly designed menu structure, STRayCi shows self-explanatory functions, which help the user to access quickly standard settings. Incomparable visualization modes, extensive analytical capabilities as well as new developed correction algorithms ensure the highest accuracy in laser beam analysis.

A wide range of beam width techniques e.g. 2nd Moment, Knife Edge, Moving Slit, Plateau, Gauss-Fit can be applied to determine quick and reliable standard beam parameters. The unique measurement tool enables the continuous monitoring of beam parameters, beam position and power density distribution. Helpful features like AOI Tracking, AOI Optimization, Zoom Functions, Look-Up Tables, etc. simplify the laser beam analysis.

The extraordinary graphical and analytical tool of STRayCi can be used for live data (LiveMode) and stored data (SaveMode) simultaneously, while each mode has its own individual functions. This makes STRayCi the most advanced analysis software on the market.

STRayCi is equipped with flexible data and image output capabilities. This permits the user to store data and images in the format that is compatible with their needs.

A clearly arranged and printable protocol view displays the chosen measurement parameters as well as the most important laser beam analysis results.

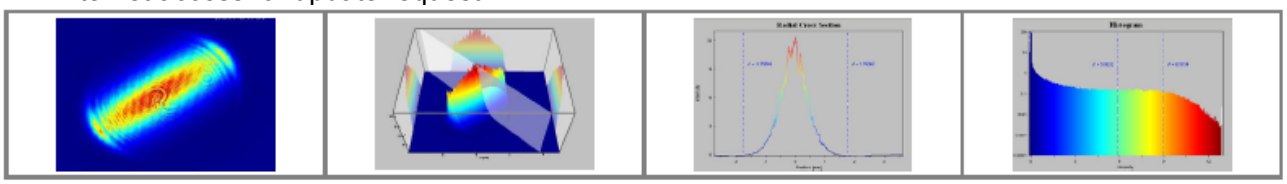
STRayCi is compatible with guidelines of the international standard organization for laser beam measurements:

- ISO 11145: Vocabularies and symbols
- ISO 11146: Beam width, propagation ratio,…
- ISO 11670: Beam positional stability,…
- ISO 13694: Beam power density distribution,…

STRayCi works only with a USB software protection lock. It is a hardware based security solutions to protect and encrypt the software against piracy.

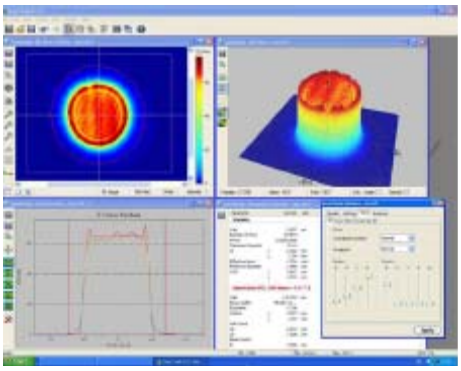
MINIMUM SYSTEM REQUIREMENTS:

- Windows XP / Vista
- Pentium IV / AMD Processor
- 128 MB graphic card, Open GL V1.4 compatible
- 100 MB free memory
- PCI / PCIe slot for FireWire card
- USB port for dongle connection
- CD / DVD-ROM drive for software installation
- Internet access for update request



STRayCi Special Features

REAL-TIME BEAM PROFILING
2D / 3D intensity plots / Cross sections / Histogram
Pointing stability (x-y fluctuation, COG- position analysis, ect.)
Parameter stability (intensity, power, center x-y, beam size)
Parameter results (beam statistics, beam width, beam parameter)



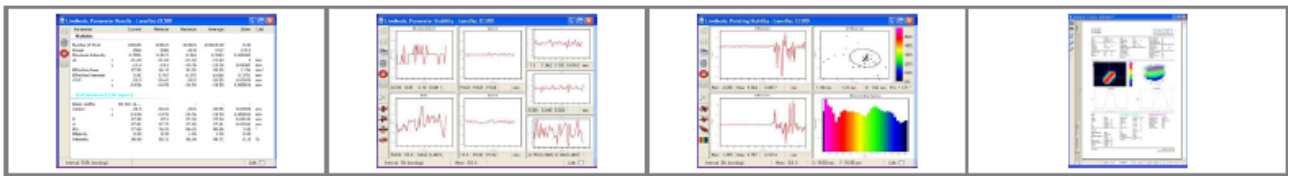
CAMERA CONTROL
Multiple camera support
Different measure types
User-selectable exposure time and gain factor, auto-exposure time
Floating average and variable brightness

ANALYSIS FUNCTIONS
Beam statistics (power, max intensity, COG, etc.)
Beam width (2nd Moment, Gauss / Super-Gauss-Fits, Plateau, Knife Edge, Moving Slit, ect.)
Beam parameter (beam width, ellipticity, uniformity, etc.)

CALIBRATION AND CORRECTION TOOL
Background subtraction, auto-background
Pixel correction technology (offset correction, linearity, etc.)
Power calibration

OTHER FEATURES
User-defined Area of Interest (AOI)
AOI tracking and optimization
Color palettes incl. auto-contrast function
Zoom functions
2D profile arithmetic operations, filters, transformations, etc.
E-mail support

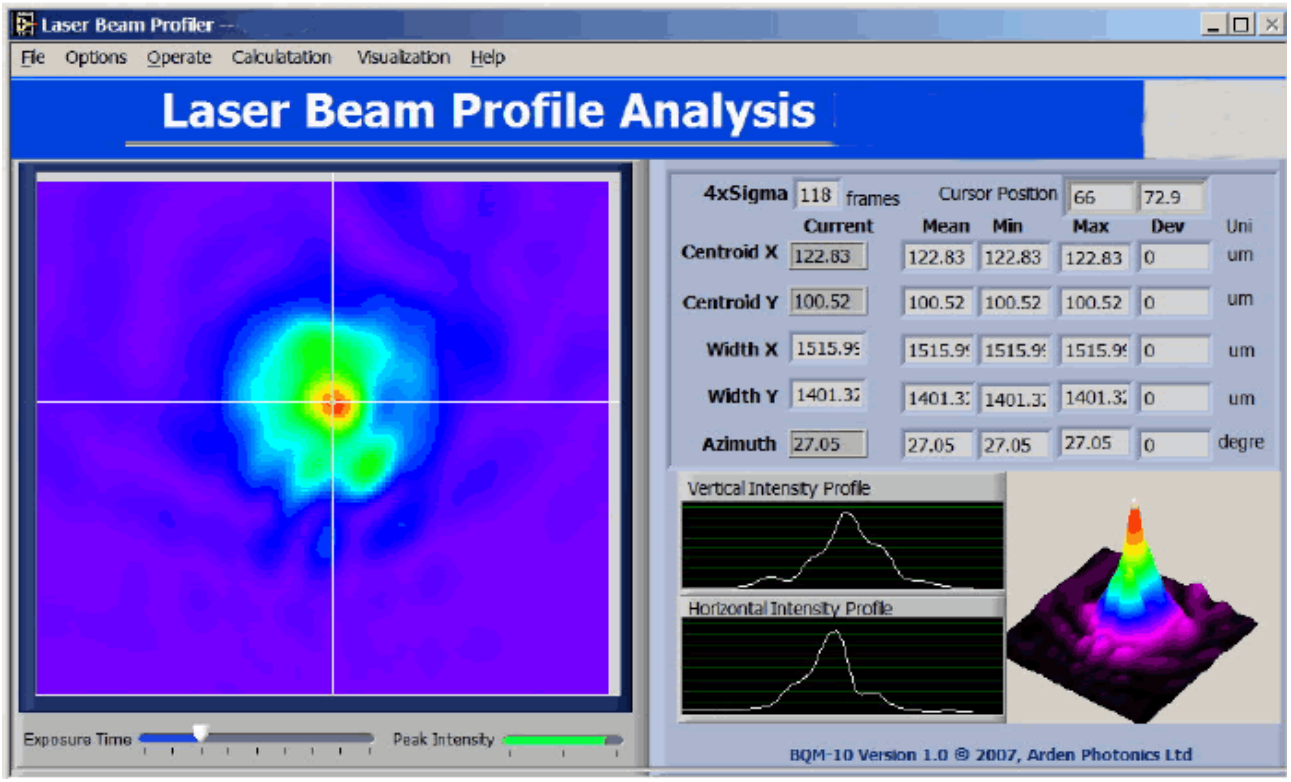
FLEXIBLE OUTPUT
Data: txt, tiff
Image: jpeg, png, bmp, gif, tiff
Protocol: pdf



STBQM-10 Beam Profile Analysis

The STBQM10 laser beam profiler is a high precision, CCD based beam profiler for use with lasers with wavelengths between 190 and 1100 nm. Allied with our powerful but intuitive software package, the BQM10 makes quick and accurate characterization of your lasers a reality.

The high quality 12-bit CCD array gives excellent resolution. Features include USB2.0 interface means portability and ease of use, RJ45 GPI/O connector for control of synchronization of lighting and 32MB onboard memory for frame buffering. Thus, the STBQM10 can be easily transferred to different laptop or desktop computers. The user interface is simple and intuitive but with many useful features.



Specifications:

- Parameters of ISO 11146 series of standards
- ½" format CCD 1392x1040 array with 4.65um square pixels
- 12-bit digitization – 60dB dynamic range
- No frame grabber required (32MB RAM on-board memory)
- USB2.0 direct connection with no external power supply required
- Compact (45x45x56mm) and lightweight (130grams)
- 15 fps at 1392x1040, 30 fps at 640x480
- Measures both CW and pulsed beams
- Second-moment and Gaussian fit
- ~3% beam diameter accuracy

The STBQM10 laser beam profiler comes with the following
- Optical head
- User software on CD
- Cables
- User manual

Options -
Wavelength range - 350nm to 1100nm

Accessories -

STBQM - 100	Variable attenuator
STBQM - 110	Set of 6 ND filters, screw mount
STBQM - 120	Beam pick off

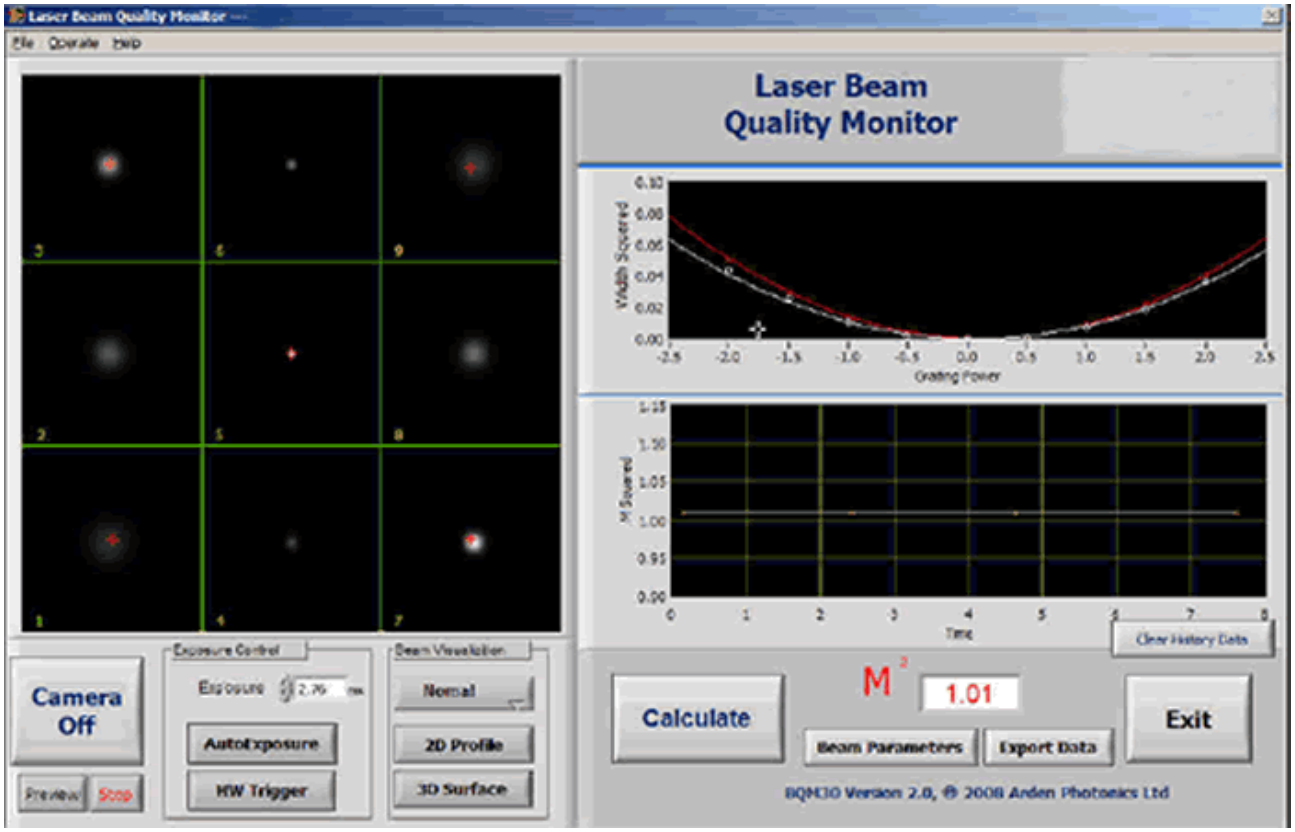
STBQM-30 Beam Quality Monitor (M^2)

The STBQM-30 is designed to allow single shot measurement of laser beam propagation characteristics. The real-time measurement capability and easy set-up make it an ideal tool for monitoring changes in beam parameters of CW and pulsed lasers.

The STBQM-30 utilizes the patented distorted diffraction grating known as IMPTM (Image MultiPlex) grating developed by QinetiQ plc in the UK, to acquire intensity data from nine image planes along the axis of the beam simultaneously. This enables beam propagation parameters to be calculated from a single frame of data from the 12-bit CCD array giving a true one-shot measurement capability. The camera operates at 0.15 mW per sq cm for CW operation, 1.0 mJ per sq cm for pulsed operation. Would need the filters if power/energy density is higher.

Product highlights:
- Parameters of ISO 11146 series of standards
- Real time measurement
- Easy to set up - speeds up analysis
- USB2.0 direct connection with no external power supply required
- Small form factor (45mm H x 45mm W x 170mm L)
- Second-moment and Gaussian fit
- 5% M2 accuracy

Typical applications:
- Laser, LD, LED and VCSEL monitoring
- Measuring pulsed lasers
- Laser beam process control e.g. during warm-up



The STBQM30 range of laser beam quality monitor comes with the following

- Optical head
- User software on CD
- Cables
- User manual

STBQM30 gratings are optimised for a particular wavelength so please specify the wavelength you want fitted as standard. The following gratings are available.
G1064 - 1064nm
G532 - 532nm
Others available on request .

Accessories -
STBQM-100: Variable attenuator
STBQM-110: Set of 6 ND filters, screw mount
STBQM-120: Beam pick off

STBP Laser Beam Profiler

The Laser Beam Profiler provides high resolution real-time monitoring and quantitative characterization of spatial beam intensity distributions. Primarily designed for excimer lasers, it may be utilized for all pulsed or CW lasers as well as for incoherent sources, covering an extremely wide spectral range from NIR to soft X-rays. The UV/EUV sensitivity is achieved by a quantum conversion coating on the CCD chip.

A variety of different sensor types (large/small area, highest spatial resolution, sensitivity and dynamic range) are available and can be adapted to specific applications. The software supports also periphery devices like adaptive mirrors, stepper motors, attenuators, shutters or power monitors. Automated or remote-controlled measurements are facilitated by the help of a powerful macro language.

The applications comprise:

- Determination of beam parameters according to ISO 11146
- Diagnosis of pointing stability (ISO 11670)
- Pulse-to-pulse fluctuations
- Beam propagation analysis (caustic measurement)
- Characterization of beam shape (uniformity, steepness) according to ISO 13694 (especially for homogenized beams)
- On-line laser beam inspection (e.g. recognition of “hot spots”)
- Optimizing of laser operational parameters
- Alignment of optical components

Special Features:

- Wide spectral range: 1064 … 13nm
- Small and large area CCD sensors
- USB 2.0 interface (ideal for laptop)
- High dynamic range (12/14 bit)

Applications:

- Beam diagnostics (NIR, Vis, UV, EUV)
- ISO beam parameters
- Beam propagation/focusability
- M^2 (caustic measurement)

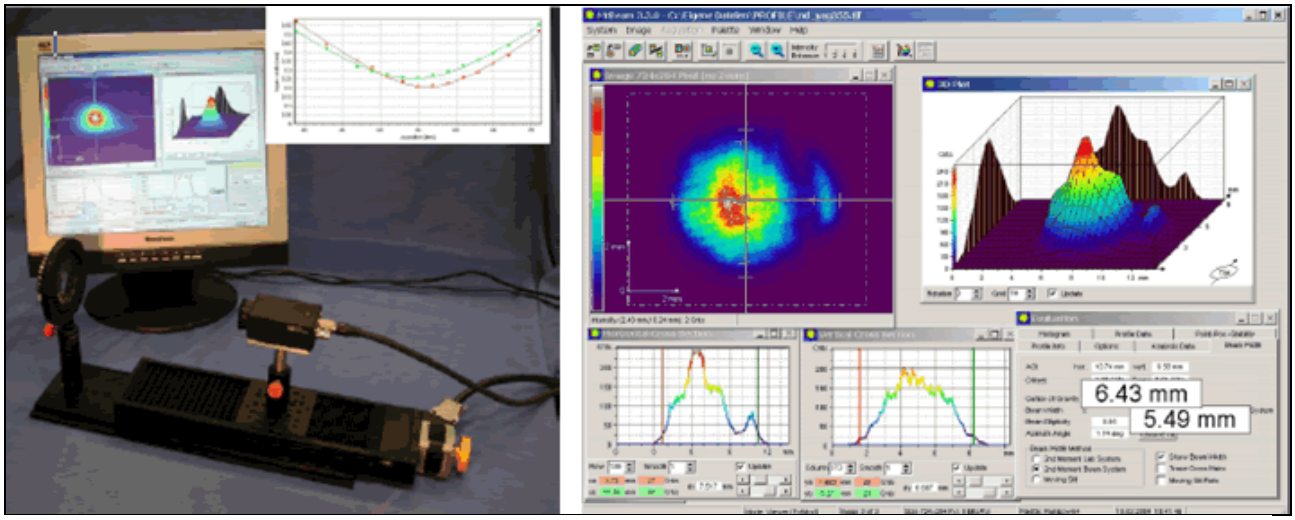
STBC Laser Beam Characterization

Beam Parameters

Quantitative determination of all relevant laser beam parameters from the acquired profiles is achieved with the help of the comprehensive beam characterization software “MrBeam”, which makes use of standard ISO evaluation procedures.

Beam parameters according to ISO standards:

- Beam width 2nd moment (ISO 11146)
- Divergence, M^2 (with caustic setup; ISO 11146)
- Pointing stability (ISO 11670)
- Beam shape/uniformity (ISO 13694)



Software:

- Various acquisition modes: ‘grab’, ‘averaging’, ‘floating average’
- Evaluation of beam parameters: beam width (2nd moment, centroid, ellipticity, uniformity, relative pulse energy, pointing stability etc.
- 2D profile arithmetics (ADD, SUB, MULT, DIV etc.)
- Selection of area-of-interest for analytic beam evaluations
- Real-time display and evaluation of cross-sections, 3D graphics
- Profile-fit (Gaussian, super-Gaussian, top-hat etc.)
- Colour palettes incl. Analytic functions (e.g. ‘intensity threshold’)
- Easy-to-use ‘zoom’-functions
- Comprehensive user-programmable macro language
- Export of all data and profiles

The system includes:

- Digital camera (USB 2.0 interface for note-book or PC)
- Beam analysis software

Optional extensions:

- Translation stage (e.g. for caustic measurement)
- Hartmann-Shack wavefront sensor
- Adaptive mirror for closed-loop beam stabilization
- Trigger/delay generator

Sintec Optronics Pte Ltd
10 Bukit Batok Cres #07-02 The Spire Singapore 658079
Tel: +65 63167112 Fax: +65 63167113

Laser Wavelength Meter

The WaveMaster measures the wavelength of both CW and pulsed lasers of any repetition rate. The wavelength can be displayed in GHz, wavenumbers, or nanometers, with vacuum and air readings available. The WaveMaster will read the peak wavelength of sources as wide as 2nm from 380nm to 1095nm. Bandwidths wider than 2nm can be accommodated at the longer wavelengths.

The Wavemaster is easy to use. Just turn on the readout and get the beam within 10 degrees of normal incidence to the sampling probe. The probe has a 2-meter fiber optic cable and takes up a minimum of beam path space. Most intensity variances are automatically accommodated, but for the strongest and weakest signals a front panel attenuator adjustment and intensity readout quickly afford accurate readings. No special triggering modes or setups are required for pulse capture.

The WaveMaster is portable with AC and battery power. The large easy-to-read display is backlit and has adjustable contrast control for easy viewing. Configuration settings are maintained in memory and retrieved on start-up for convenience. Communication with the WaveMaster is also easy with built-in RS-232 and an optional GPIB interface.

The WaveMaster is easy to read with front panel adjustments of contrast and back-lightning for the extra-large display. Parameters that have been set-up are clearly displayed in addition to signal intensity and pulse retrieved indicators. When in the CW mode of operation the display is updated at an easy to read 3Hz rate. While in the pulse mode the display is updated at 3Hz and maintained for 15 seconds after a pulse for reading single events.

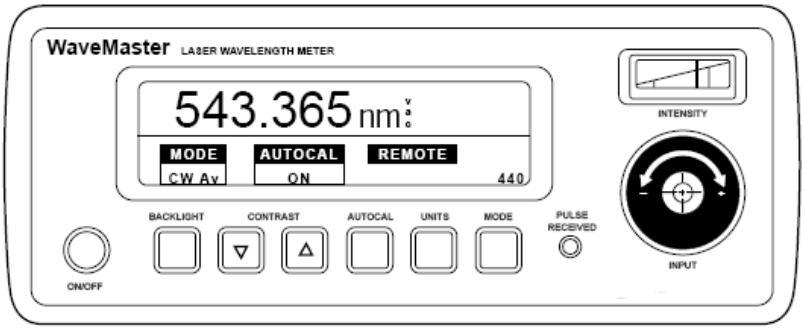
Calibration is maintained by sophisticated algorithms that monitor the WaveMaster's response. Periodically and upon indication from the algorithms the WaveMaster is referenced to the fundamental Ne lines.

FEATURES

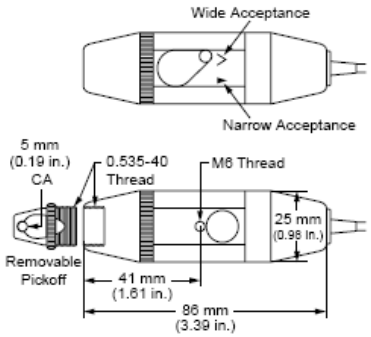
- 380 nm to 1095 nm Wavelength Range
- RS-232 and Optional GPIB Interfaces
- 0.005 nm accuracy
- 0.001 nm resolution
- Internal self-calibration
- Fiber input with sampling probe

Part Number	Description
LWM33-2650	WaveMaster Laser Wavelength Meter
LWM33-2627	WaveMaster Laser Wavelength Meter with GPIB

Front View



Sampling Probe



	WaveMaster
Wavelength Coverage	380-1095 nm
Accuracy	0.005 nm
Resolution	0.001 nm
Min. Pulse Rep Rate	Single shot
Max. Pulse Rep Rate	CW
Max. Signal Bandwidth	2nm @ 400nm 3nm @ 600nm 5nm @ 1000nm
Min. Signal	20µW CW @632nm 2mJ pulsed @ 1064nm
Max. Signal	100mW CW @ 632nm 100mJ pulsed @ 1064nm
Display Update	3 Hz
Size	281mm wide x 105mm high x 352mm deep
Storage Conditions Relative Humidity Shock	-10°C to 50°C Non-condensing and <80% <4g
Use Conditions Relative Humidity Shock	-10°C to 50°C Non-condensing and <80% <4g
Power Supply (supplied)	Universal 90-250 VAC, 40-72 Hz in 12 VDC out

Back View