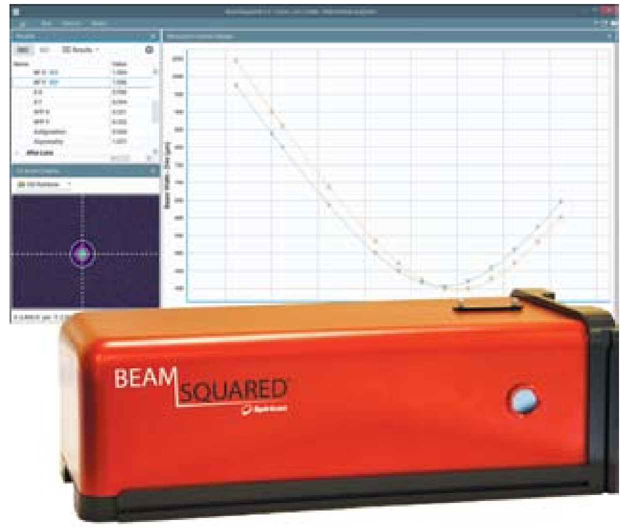
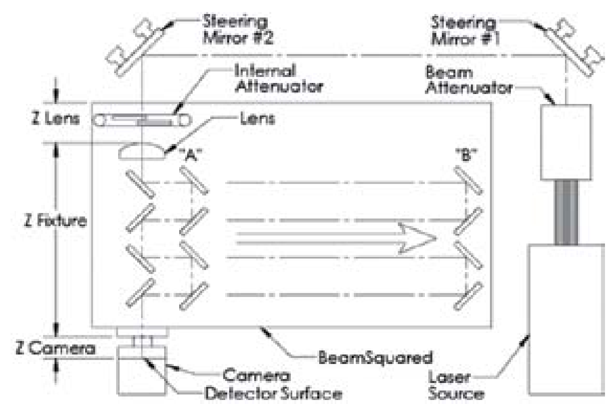
3.7.1 Camera Based Beam Propagation Analyzer: M^2

3.7.1.1 BEAM SQUARED



- ISO compliant
- Automatically measure your beam quality in under 1 minutes
- Tune your laser for best operation
- Specifically developed for continuous usage
- Unequaled accuracy using patented Ultracal™ Calibration
- Long optical train & automatic attenuation adjustment
- Flexible mounting configurations, install horizontal or vertically
- Pulsed and CW for most beam diameters and powers
- Compact and portable
- Detectors from 266nm to 10.6µm

The BeamSquared system is a compact and fully automated tool for measuring the propagation characteristics of CW and pulsed laser systems from the UV to NIR to Telecom wavelengths. Users can also measure wavelengths above 1.8 microns, including CO2 and terahertz in manual mode (a bench set-up; without the automated optical train) with a Pyrocam IV or IIIHR. Our longer optical train and patented UltracalTM Calibration makes BeamSquared the most accurate product on the market and is ISO 11146 compliant. Its operational robustness and reliability ensures continuous use applications in industry, science, research and development.

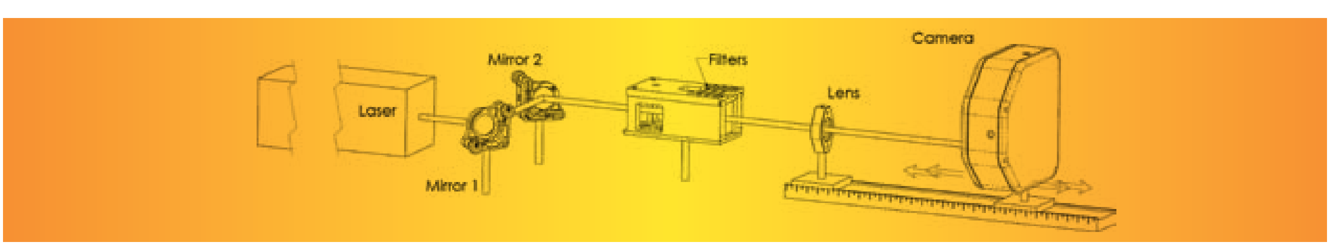


Automatic M^2 - at Production Speeds

The Beam Squared optical train uses a fixed position lens with movable mirrors and camera. The mirrors that direct the focused beam into the camera are moved to precise locations, translating the beam through the near field, the waist, and the far field regions. All these measurements and translations, as well as incremental beam attenuation, are automatically controlled by the BeamSquared software. Design improvements in the BeamSquared system have decreased the measurement reporting time by 2-3 times, making it possible to report M^2 in under a minute.

Manual M^2

Manual mode is available for wavelengths greater than NIR, particularly Terahertz and above, and for beams that are too large or too small for the BeamSquared optical system. Users are required to provide a manual translation/attenuation apparatus.



Features	
Supports both automated and manual runs	
New Hardware	
	Camera Options include: SP920, Xeva, Pyrocam III HR or IV
	RF Lens Reader
	▪ Lens must be present for operation
	▪ Lens configuration data stored with lens (Focal length, calibration wavelength, material, etc.)
	Shutter only open when in live mode
	Table and attenuator calibration at startup (homing before each run)
Supports hardware Trigger	
Faster run times than M2-200s	
New Interface	
	Selectable theme colors
	Splash screen with progress bar
2D display	
	Selectable Color Palette
	Manual Cursor when not running (Cursor at centroid otherwise)
Caustic Display	
	Selecting individual frames
	Auto Aperture
	Exclude points from run
Run Info Display	
	Displays Caution Notice when beams are non-conforming: (too dark, too bright, misaligned, too large or too small)
	Option to ignore misaligned beams
Editable Settings (Wavelength, Laser to box distance, Laser to lens and focal length in manual mode)	
Calculations	
	Frame Results (Total, Min, Peak, % in Aperture, Avg Pwr Density, Beam Width, Centroid, Peak, Cross Sectional Area)
	Laser Results (Waist Width, Divergence, Waist Location Rayleigh Length, M2, K, BPP, Astigmatism, Asymmetry)
	After Lens Results (Waist Width, Divergence, Waist Location Rayleigh Length, Astigmatism, Asymmetry)
	Effective Focal Length of lens
	Fitted/Measured Divergence
	Supported Beam Width calculations
	▪ D4 Sigma
	▪ Knife Edge 10/90 and Programmable
	▪ EPSA - Encircled Power Smallest Aperture (power in a bucket)
Multiple Runs	
	Result statistics
	Progress Indicator
Single Page Report	
	Setup information
	Results
	Statistics
	Caustic chart
Logging/Export data	
	.CVS File

Accuracy by Design

Spiricon products are known for accuracy. Using our patented Ultracal calibration method, auto aperturing to exclude noise beyond the wings of the laser beam, and long optical path, assures the user of the most accurate measurements in the industry.

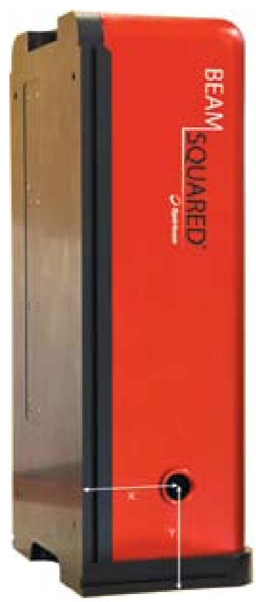
Designed by Our Customers

Guided by customer input from our widely deployed previous generation M2-200s system, Spiricon redesigned the BeamSquared to meet the challenging demands of the laser industry. The new BeamSquared system has significantly higher durability and operational robustness for continuous use in a three shifts a day, seven days a week environment. The rigid baseplate and internal optics greatly simplifies and reduces the time for initial set-up and alignment. The lens configuration data is now stored using an RF ID chip embedded in the lens holder which is uploaded automatically by the BeamSquared system when the lens cartridge is inserted in the system, eliminating the need for our customers to keep track of configuration file. Both novice and seasoned users will appreciate these new features along with the time-tested excellence that Spiricon has provided over the years.

Measurements

BeamSquared measures propagation characteristics in both the X and Y axes and displays the following parameters:

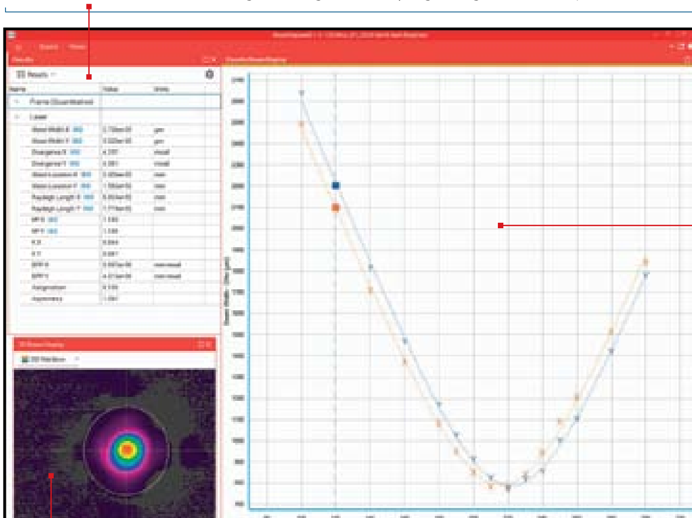
- Waist diameters
- Full angle Divergences
- Waist locations
- Rayleigh lengths
- M^2 or K and BPP factors
- Astigmatism
- Asymmetry



To optimize bench space, BeamSquared can be mounted either horizontally or vertically. Laser beam input port is the same dimension with either mounting method, X = Y, and the same as the M^2-200s that it is replacing.

Main Screen Functions

This window displays quantitative measurements of the laser parameters. These include the X and Y beam widths, M^2 or K, the divergence angles, the Rayleigh range, and other parameters shown.



This window presents measurements of beam width vs. position for a given run. After measuring a few points, the software extrapolates a curve fit. The Xs and Ys represent individual measurement points. The solid lines present the best fit hyperbola of the beam propagation equation to the measured points. The M^2 and other laser parameters are computed from the best fit hyperbola since it provides a smoothing of the data points.

This window displays the 2D or 3D beam profile of the currently measured point in the beam propagation curve. This image enables visual intuitive verification of the beam profile behavior through focus. After each run the user can click any individual measured point and observe the beam profile. Outlying or anomalous points can be automatically or manually excluded from the curve fit calculations for more accurate results.

3.7.1.1.1 Specifications

Measurements			
	M2x, M2y, Kx, Ky, BPPx, BPPy		
	Width at waist Wx, Wy		
	Divergence angle Qx, Qy		
	Waist location Zx, Zy		
	Rayleigh X, Y		
	Astigmatism		
	Asymmetry ratio		
	Statistical results are available on all measurements		
General			
Accuracy	±5% typical, ±10% waist location and Rayleigh length typical		
Measurement Cycle Time	<1 minute typical, depending on setup conditions and operating mode		
Camera Attachment	Standard C-mount, 90° camera on axis rotation		
Translation System	Step-motor driven ball screw		
Resolution	0.05mm		
Standard Optics			
	Different lenses are required for different wavelength regions, spot sizes and divergences. Four lenses are included with the SP920 systems and two lenses with the XC-130 system. See below, for nominal focal lengths. Additional lenses must be ordered separately.		
Lenses	BSQ-SP920 266-440nm UV 500mm FL (included) 430-700nm VIS 500 FL (included) 430-700nm VIS 400 FL (included) 650-1000nm NIR 400 FL (included) 1000-1700nm Extended NIR 400 FL (included)	BSQ-XC-130-A 1000-1700nm Extended NIR 400 FL (included)	BSQ-A Lens kits – optional
Attenuation Range			
	Nominally from ND 1.0 to ND 4.8. Actual values vary with wavelength.		
Damage Limits [1]			
For the SP920	.15 mW/cm2 CW mode 1.0 μJ/cm^2 pulse mode for a 10mm Both of the above for an M^2=1 @ 1064nm		
[1] **CCD cameras can be damaged by power in excess of 0.1 mW/cm^2 or energy in excess of 1 mJ/cm^2. BeamSquared employs a focusing optic. While it may be that the laser input power or energy measures well below this damage threshold, it can easily exceed these levels when focused onto the camera sensor. Use caution and error on the side of safety. CCD cameras can be costly to repair or replace.**			
For the XC-130 and Pyrocam IIHR and Pyrocam IV	See individual camera data sheets		
Optical Limits			
Wavelength Range	266 -1700nm limited by Camera The CCD camera is operational from 266 to 1100nm. InGaAs camera operates from 900 to 1700nm. Pyrocam from 1.06 to 3000μm		
Beam Size	BeamSquared Auto Mode 1mm – 10mm BeamSquared Manual Mode 0.8mm – 10mm maximum for Pyrocam IIIHR and 0.8mm – 20mm maximum for Pyrocam IV Varies with wavelength, waist size, location, and M^2		
Minimum Beam Width	SP920 XC-130 Pyrocam IIIHR or IV (manual & w/o optical train only)	36.9μm 300μm 800μm	
Environmental			
Storage Temperature	-30° C to 65° C		
Storage Humidity	95% maximum (non-condensing)		
Operating Temperature	10° C to 40° C		
Operating Humidity	95% maximum (non-condensing)		
Power Requirements[2]			
Input Voltage	90 – 264 V AC		
AC Line Current	1.6 A		
Line Frequency	47Hz to 63Hz		
[2] For the optical train only. The PC computer supplies the power for the system components, such as the CCD camera.			
Physical			
Weight	26 lbs. w/o camera		
Dimensions	See manual or web site		

3.7.1.1.2 Ordering Information

Item	Description	P/N
BSQ-SP920	BeamSquared software, software license, SP300 USB 3.0 camera, optical train, automatic and manual operation, recommended for 266nm - 1100nm wavelengths.	SP90502
BSQ-XC-130-A	BeamSquared software, software license, XC-130 USB 2.0 camera, optical train, automatic and manual operation, recommended for 900nm - 1700nm wavelengths.	SP90444
BSQ-A	BeamSquared software, software license, and optical train no camera included. For use with compatible cameras purchased. Compatible camera must be return to factory for upgrade at no additional charge. If, upon inspection the camera does not meet specifications, a repair change will be applicable.	SP90445
BSQ-PY-M	BeamSquared software and software license for manual M^2 measurement using a Pyrocam camera (optical train and Pyrocam camera not included).	SP90410
Options		
BSQ-Lens Kit 266-1000		SP90449
BSQ-Lens Kit 650-1700		SP90450
BSQ-Lens Kit UV 500mm		SP90451
BSQ-Lens Kit VIS 500mm		SP90452
BSQ-Lens Kit VIS 400mm		SP90453
BSQ-Lens Kit NIR 400mm		SP90454
BSQ-Lens Kit Extended NIR 400mm		SP90455
BSQ/BGS-KEY	Includes BeamGage Standard software license in addition to BeamSquared software license	SP90507
BSQ/BGP-KEY	Includes BeamGage Professional software license in addition to BeamSquared software license	SP90508