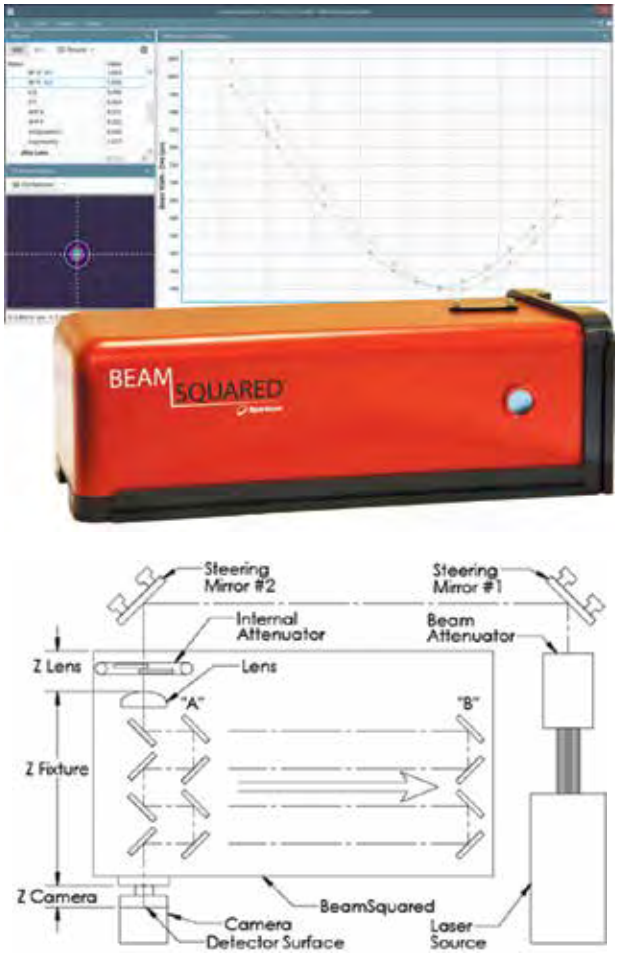
3.7.1 Camera Based Beam Near-Field Propagation Analyzer: M^2

3.7.1.1 BeamSquared®

- 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



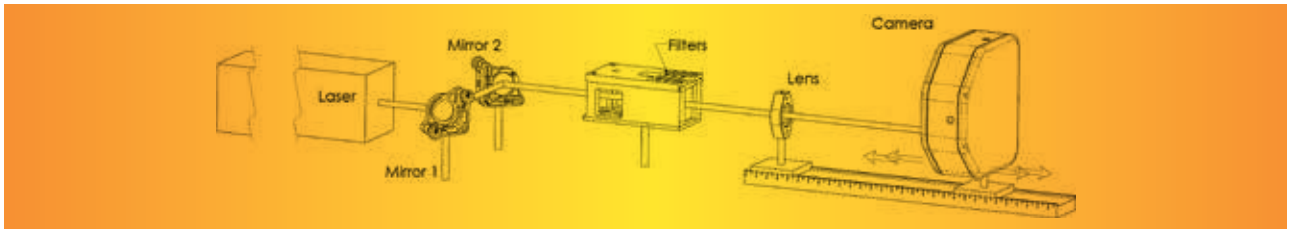
The BeamSquared® system is a compact and fully automated tool for measuring the propagation characteristics of CW and pulsed laser systems from the UV to NIR to Telecom wavelengths. Users can also measure wavelengths above 1.8 microns, including CO_2 and terahertz in manual mode (a bench set-up; without the automated optical train) with a Pyrocam™ IV or IIIHR. Our longer optical train and patented Ultracal™ 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 BeamSquared 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.



Software Features

Features	
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
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

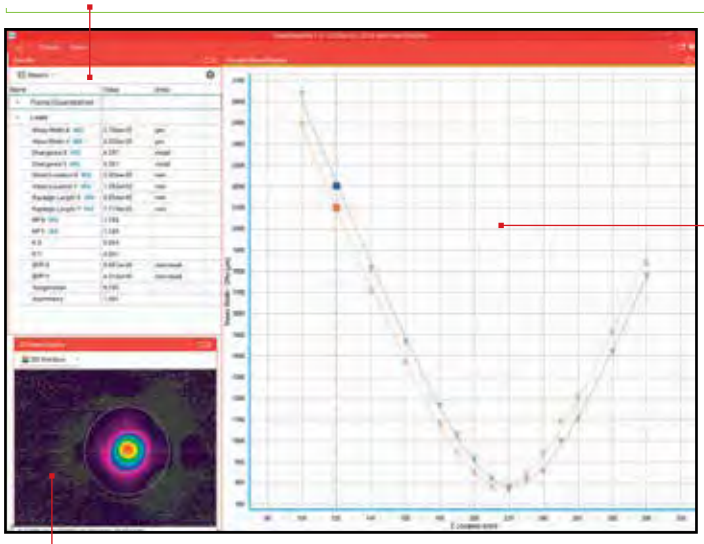
BeamSquared measures propagation characteristics in both the X and Y axes and displays the following parameters:

- 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.

Specifications

Model	BSQ-SP920	BSQ-XC130	BSQ-A	BSQ-PY-M
Beam Profiling				
Camera model	SP920	XC130	BeamSquared® software, software license, and optical train, no camera included	Pyrocam™ IIIHR or Pyrocam™ IV
Sensor type	Silicon CCD	InGaAs CCD		Software only, camera and optical train not included. See individual camera data sheets
Wavelengths	266 – 1100nm	900 – 1700nm (1)		
Active area	7.1mm x 5.3mm	9.6mm x 7.6mm		
Elements	1624 x 1224	320 x 256		
Effective pixel	4.4µm x 4.4µm	30µm x 30µm		
Dynamic range	60dB	68dB		
Frame rate	15 fps	100 fps		
Interface	USB 2.0 and 3.0			
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			
Translation stage resolution	0.05mm			
Standard optics				
Lenses included (2)	266-440nm UV 500mm FL 430-700nm VIS 500mm FL 430-700nm VIS 400mm FL 650-1000nm NIR 400mm FL 1000-1700nm Extended NIR 400mm FL	1000-1700nm Extended NIR 400mm FL 650-1000nm NIR 400 FL	266-440nm UV 500mm FL 430-700nm VIS 500mm FL 430-700nm VIS 400mm FL 650-1000nm NIR 400mm FL 1000-1700nm Extended NIR 400mm FL	N/A
Optional lenses (3) (4) *Not part of the standard BSQ kit	266-440nm UV 750mm FL 266-440nm UV 1000mm FL 430-700nm VIS 750mm FL 430-700nm VIS 1000mm FL 650-1000nm NIR 750mm FL 1000-1550nm Extended NIR 750mm FL	650-1000nm NIR 750mm FL 1000-1550nm Extended NIR 750mm FL	266-440nm UV 750mm FL 266-440nm UV 1000mm FL 430-700nm VIS 750mm FL 430-700nm VIS 1000mm FL 650-1000nm NIR 750mm FL 1000-1550nm Extended NIR 750mm FL	N/A
Attenuation range				
	Nominally from ND 1.0 to ND 4.8. Actual values vary with wavelength.			N/A
Damage limits (5)				
	0.15 mW/cm² CW mode 1.0 µJ/cm² pulse mode Both of the above for an M²=1 @ 1064nm	100 mW/cm²	Depends on type of the camera	See camera data sheets
Optical limits				
Wavelengths	266 - 1100nm	900 - 1700nm	Depends on type of the camera	1.06 - 3000µm
Beam size	BeamSquared Auto Mode 1mm – 10mm Varies with wavelength, waist size, location, and M²			Pyrocam IIIHR 0.8mm – 10mm max Pyrocam IV 0.8mm – 20mm max Depends on customer mechanics and lens
Minimum beam width	44µm	300µm	N/A	800µm
Software				
BeamSquared Software	Fast scan method (1 minute) for automatic (ISO) and manual M2 measurement			
General				
Storage temperature	-30° C to 65° C			N/A
Storage humidity	95% maximum (non-condensing)			N/A
Operating temperature	10° C to 40° C			N/A
Operating humidity	95% maximum (non-condensing)			N/A
Power requirements (6)				
Input voltage	90 – 264 V AC			N/A
AC Line current	1.6 A			N/A
Line frequency	47Hz to 63Hz			N/A
Weight	26 lbs. w/o camera			N/A
Dimensions	217.2mm X 459.5mm X 156.3mm			N/A
Compliance	CE, UKCA, China RoHS			
Ordering information				
Part Number	**SP90502**	**SP90444** (7)	**SP90445**	**SP90410**

Notes:
(1) For wavelengths between 1300-1400nm inner reflections have been observed that may impact beam measurement
(2) Different lenses are required for different wavelength regions, spot sizes and divergences, Additional lenses must be ordered separately.
(3)For selection of optimal BeamSquared lens, use Beam Profiler Finder.
(4)These lenses have been calibrated for measurement of lasers with Rayleigh length up to 20 meters, for longer Rayleigh lengths, please use Beam Profiler Finder.
(5) CCD cameras can be damaged by power in excess of 0.15 mW/cm² or energy in excess of 1 µJ/cm². 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.
(6) For the optical train only. The PC computer supplies the power for the system components, such as the CCD camera.
(7) P/N for USA only, for any other country please consult Ophir representative

Accessories Ordering Information

Item	Description	P/N
BSQ-SP920-A	An SP920 camera licensed for BeamSquared®. Sold as an accessory for those also purchasing a BSQ-XC130	**SP90521**
BSQ-Lens Kit 266-1550	Lens kit that includes 5 BeamSquared lenses: 500mm UV, 500mm VIS, 400mm VIS, 400mm NIR, 400mm XNIR	**SP90449**
BSQ-Lens Kit 650-1700	Lens kit that includes 2 BeamSquared lenses: 400mm NIR, and 400mm XNIR.	**SP90450**
BSQ-Lens UV 500mm	Single BeamSquared lens, 500mm focal length, A/R coated for 266-440nm	**SP90451**
BSQ-Lens VIS 500mm	Single BeamSquared lens, 500mm focal length, A/R coated for 430-700nm	**SP90452**
BSQ-Lens VIS 400mm	Single BeamSquared lens, 400mm focal length, A/R coated for 430-700nm	**SP90453**
BSQ-Lens NIR 400mm	Single BeamSquared lens, 400mm focal length, A/R coated for 650-1000nm	**SP90454**
BSQ-Lens XNIR 400mm	Single BeamSquared lens, 400mm focal length, A/R coated for 1000-1550nm	**SP90455**
BSQ-Lens XNIR 600mm	Single BeamSquared lens, 600mm focal length, A/R coated for 1000-1550nm	**SP90485**
BSQ-Lens UV 750mm	Single BeamSquared lens, 750mm focal length, A/R coated for 266-440nm	**SP90554**
BSQ-Lens VIS 750mm	Single BeamSquared lens, 750mm focal length, A/R coated for 430-700nm	**SP90555**
BSQ-Lens NIR 750mm	Single BeamSquared lens, 750mm focal length, A/R coated for 650-1000nm	**SP90556**
BSQ-Lens XNIR 750mm	Single BeamSquared lens, 750mm focal length, A/R coated for 1000-1550nm	**SP90557**
BSQ-Lens UV 1000mm	Single BeamSquared lens, 1000mm focal length, A/R coated for 266-440nm	**SP90558**
BSQ-Lens VIS 1000mm	Single BeamSquared lens, 1000mm focal length, A/R coated for 430-700nm	**SP90559**
BSQ SP300 to SP920 upgrade	Camera upgrade	**SP90511**
BGS license for BSQ-SP920	Includes BeamGage Standard software license in addition to BeamSquared software license	**SP90214**
BGP license for BSQ-SP920	Includes BeamGage Professional software license in addition to BeamSquared software license	**SP90244**
BGP license for BSQ-XC130	Includes BeamGage Professional software license in addition to BeamSquared software license	**SP90508**
BSQ-XC130-KEY	Includes BeamSquard software license for XC-130 camera	**SP90503**