3.3.2 NanoScan™ 1 for Large Beams

Scanning Slit Beam Profiler For High Accuracy Dimensional Measurement

NanoScan 1 is a PC-based instrument for the measurement and analysis of optical beam spatial profiles in accordance with ISO standards. Beam profiles are measured using the International Standard ISO 11146. Scanheads that are fitted with an optional power feature can measure power in accordance with ISO 13694.

The system comprises a scanhead for sensing the laser beam, a USB 2.0 controller, and NanoScan software. An optional automation feature includes an ActiveX automation server.

NanoScan uses moving slits, one of the ISO Standard scanning aperture techniques. Measurement is possible for beam sizes from microns to centimeters at beam powers from microwatts to over kilowatts, often without attenuation. Detector options (silicon, germanium, and pyroelectric technologies) allow measurement at wavelengths from the ultraviolet to the far infrared. It can simultaneously measure multiple beams and offers an optional power meter for scanheads with silicon and germanium detectors.

Profiles are acquired with 12-bit digitization, and analyzed for real-time updates up to the maximum scanhead scan rate of 20Hz. With NanoScan, beam profile measurement is extremely easy: simply position the scanhead in the beam path and within seconds the system does the rest.
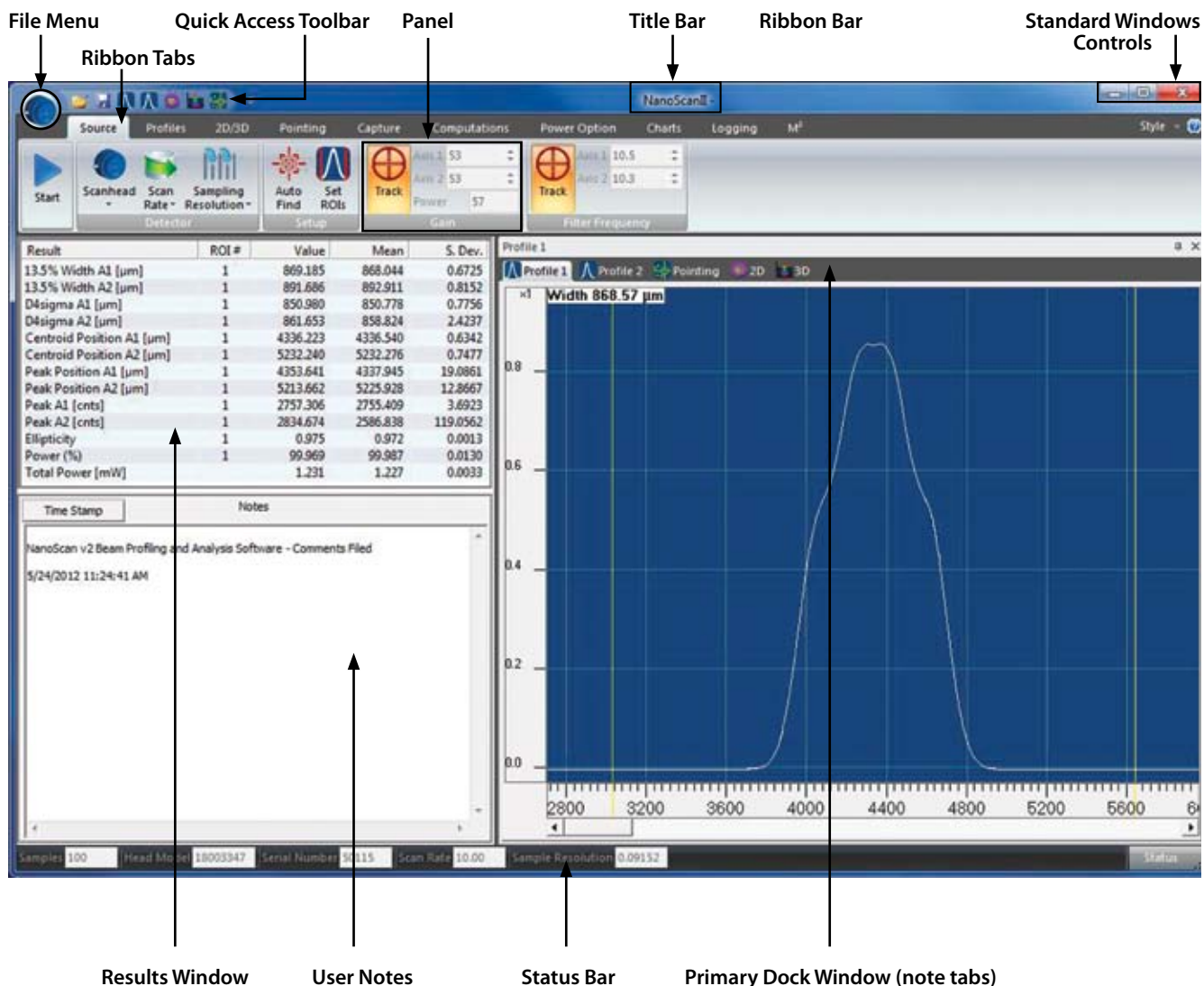
Benefits

- All NanoScan systems are calibrated to a NIST traceable source to ensure the ultimate in accuracy.

- The software finds a beam in less than 0.3 seconds and displays real-time updates up to 20Hz.

- The Z-axis datum plane of the NanoScan is known to ±25µm making the locating of beam waist position simple and accurate.

- Along with the ability to measure pulsed beam diameters, the NanoScan accurately measures and reports the pulse frequency of the laser, ensuring that the pulsed beam measurements are stable and accurate.

- The sampling interval for beam measurements is adjustable to as little as 5.7nm, providing the extreme accuracy required to measure very small beams.

- Profile averaging and rolling averages are available to improve signal to noise.

- NanoScan software has built-in capability to control a mechanical linear stage for measurement of beam caustic.

- Software has a built-in M^2 Wizard to assist in making manual propagation ratio measurements.

- Time charts allow any beam result to be charted over time.

- Results logging to text files.

- Optional ActiveX Automation commands with samples of automation programs for Excel VBA, LabView and Visual Basic.net.

- Optional power meter with silicon and germanium scanhead.

Measure Your Beam as Never Before

The system has a USB 2.0 interface and operates with the latest Microsoft operating systems 64/32-bit Windows 7, and provides deep, 12-bit digitization of the signal for enhanced dynamic range up to 35dB optical power. The digital controller improves the accuracy and stability of the beam profile measurement by orders of magnitude. It is now possible to measure beam size and beam pointing with a 3-sigma precision of 1µm or better. The software controllable scan speed and a "peak-connect" algorithm allow the measurement of pulsed and pulse width modulated lasers with frequencies of a few kHz and higher with any detector.*

*The minimum frequency is a function of the beam size and the scan speed. This is a simple arithmetic relationship; there must be a sufficient number of pulses during the time that the slits sweep through the beam to generate a meaningful profile. Please refer to Photon's Application Note, Measuring Pulsed Beams with a Slit-Based Profiler.

NanoScan Main Display Screen

File Menu   **Quick Access Toolbar**   **Panel**   **Title Bar**   **Ribbon Bar**   **Standard Windows Controls**

Ribbon Tabs

Results Window   **User Notes**   **Status Bar**   **Primary Dock Window (note tabs)**

## The Most Versatile and Flexible Beam Profiling System Available

Photon's NanoScan scanning slit profilers provide major performance enhancements while maintaining the ease-of-use and flexibility that customers have come to expect with its predecessor, the world-renowned BeamScan. NanoScan scanheads are available to measure CW and pulsed beams across the entire spectral range from UV to far infrared.

3.3.2 Beam Analysis

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See Your Beam As Never Before

The Graphical User Interface (GUI) of NanoScan is new. Dockable and floatable windows plus concealable ribbon tool bars empower the NanoScan user to make the most of a small laptop display or a large, multi-monitor desktop PC.
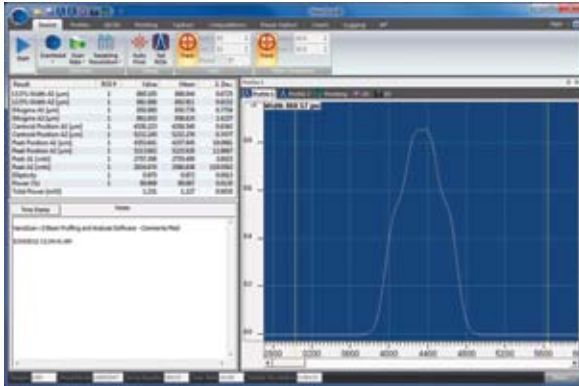
Simple docked view
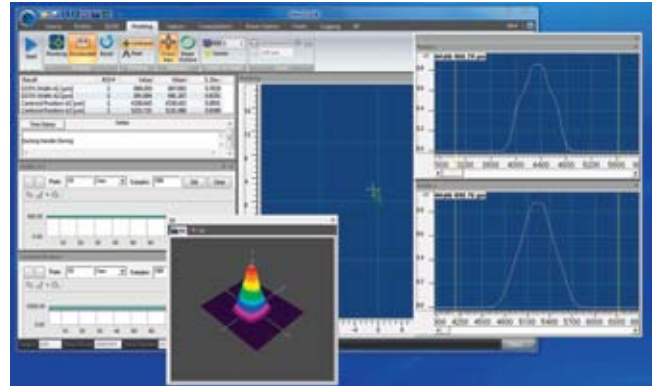
Both docked and undocked windows

Measured Beam Results

From 1989 through 1996, John Fleischer, past President of Photon Inc., chaired the working laser beam width ISO/DIN committee that resulted in the ISO/DIN 11146 standard. The final approved standard, available in 13 languages, is a compromise based on many years of work by the committee. The standard governs profile measurements and analysis using scanning apertures, variable apertures, area sensors and detector arrays. NanoScan measures spatial beam irradiance profiles using scanning slit techniques. The standard NanoScan uses the moving-slit method, approved by International Standard ISO/DIN 11146.

Results measured include:

- Beam Width at various clip levels
- Centroid Position
- Peak Position
- Ellipticity
- 1D Gaussian Fit
- Beam Divergence
- Beam Separation
- Pointing Stability
- ROI Power (optional)
- Total Power (optional)
- Peak (in digitizer counts)
- Pulsed Laser Repetition Rate

Result	ROI #	Value	Mean	S. Dev.
13.5% Width A1 [µm]	1	863.328	864.612	0.7082
13.5% Width A2 [µm]	1	876.317	875.622	0.9432
D4sigma A1 [µm]	1	849.062	849.700	1.5084
D4sigma A2 [µm]	1	842.054	840.924	2.3751
Centroid Position A1 [µm]	1	1.111	-0.133	0.5622
Centroid Position A2 [µm]	1	-1.730	0.275	1.2221
Peak Position A1 [µm]	1	-11.521	-19.890	5.6014
Peak Position A2 [µm]	1	4.156	8.732	6.9860
Peak A1 [cnts]	1	2812.438	2810.688	4.0486
Peak A2 [cnts]	1	2687.898	2678.320	5.5879
Ellipticity	1	0.806	0.807	0.0023
Power [%]	1	99.994	99.979	0.0273
Total Power [mW]		1.202	1.203	0.0002

Example of the many measurements that can be made and the precision you can expect
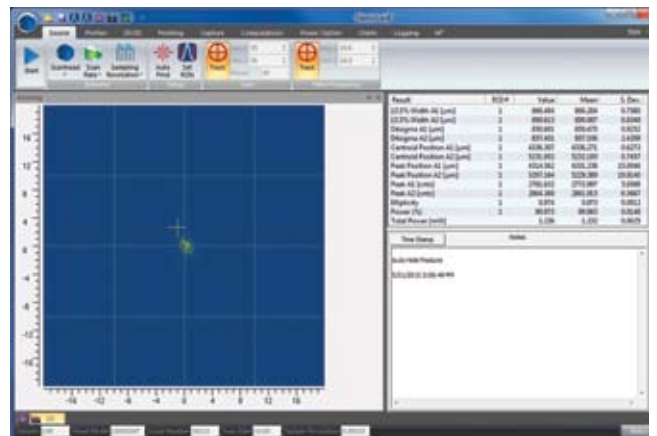
Knowing pointing stability is a critical factor in laser performance

3.3.2 Beam Analysis

Multiple Beam Analysis Software

The NanoScan software is an integrated package for Microsoft Windows operating systems, it can measure from one to 16 beams in the NanoScan aperture, all with sub-micron precision. The optimal-pro software includes ActiveX automation for users who want to integrate the NanoScan into OEM systems or write their own user interface screens.

M^2 Wizard

M-squared (M^2) software Wizard is an interactive program for determining the "times diffraction limit" factor M^2 by the Rayleigh Method. The M^2 Wizard prompts and guides the user through a series of manual measurements and data entries required for calculating M^2. For automated and automatic M^2 measurements the NanoModeScan option is required.

Pulsed Laser Beam Profiling

In addition to profiling CW laser beams, NanoScan can also profile pulsed laser beams with repetition rate in the 1kHz range and above. To enable the measurement of these pulsed lasers, the NanoScan profiler incorporates a "peak connect" algorithm and software-controlled variable scan speed on all scanheads. The accuracy of the measurement generally depends on the laser beam spot size and the pulse-to-pulse repeatability of the laser. The NanoScan is ideal for measuring Q-switched lasers and lasers operating with pulse width modulation power (PWM) control. In the past few years, lasers with pico- and femtosecond pulse durations have begun to be used in many applications. Although these lasers add some additional complication to the measurement techniques, the NanoScan can also measure this class of laser.

Optional Power Meter

The silicon and germanium NanoScan systems offer the 200mW power meter as an option. The power meter can be calibrated against the user's ISO- or NIST- traceable power meter. The 200mW power meter has a quartz attenuator window that provides a uniform response across a broad wavelength range with a 1.5% accuracy when used in the same geometry as calibrated.

The power meter screen in the software shows both the total power and the individual power in each of the beams being measured. The power meter option is not available with pyroelectric detectors.

Optional Automation Interface

The Pro model scanheads implement an Automation Server that can be used by an Automation Client written in Visual Basic for Applications (VBA), C/C++ or by an application with support for ActiveX Automation, such as Microsoft Excel, Microsoft Word or National Instruments' LabVIEW.
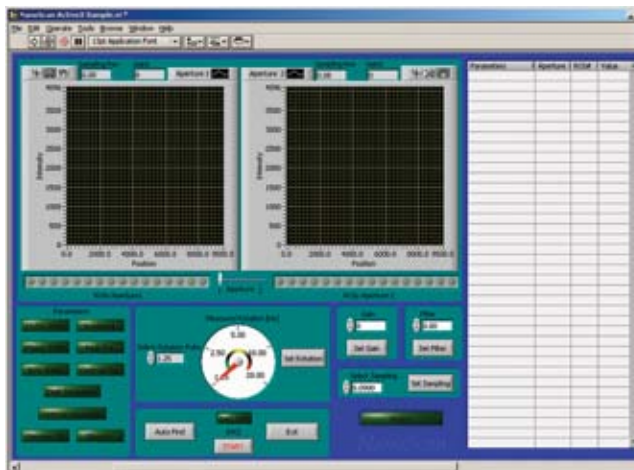
Full featured application examples are included to help your learning curve when embedding NanoScan - PRO into an automation application

NanoScan Configurations

Detector Type	Power Range	Wavelength	Aperture	Slits	Scanhead Size	1/e² beam diameter range
Silicon	~100nW-~100mW	190nm-950nm	25mm	25μm	100mm	20μm-~21mm
Germanium	~1μW-~100mW	700nm-1800nm	12mm	25μm	100mm	20μm-~10mm
Pyroelectric	100mW-100W	200nm- >20μm	20mm	25μm	100mm	100μm-14mm

* Assumes Gaussian (TEM$_{00}$) beam

The power that can be handled by the NanoScan is dependent on the wavelength of the light to be measured. The wavelength of light determines both its reflectivity from the slit surfaces and the energetic nature of the interactions with materials. As a rule of thumb, there are three basic wavelength regimes that govern how much power the scanhead can handle:

- 3μm to FIR (>20μm) –100W maximum pyroelectric detector

- 700nm to 3μm—25W maximum pyroelectric detector; 1W germanium detector

- 190nm to 700nm—3W maximum pyroelectric detector; 1W silicon detector

Power levels above these for any of these wavelengths can be considered "High Power." See the High Power NanoScan section for appropriate products. **Consult the damage thresholds charts found in the manual before placing an order or exposing any NanoScan slit profiler to a laser beam.**

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NanoScan Acquisition and Analysis Software

*Feature		NanoScan Standard	NanoScan Professional (all features in Standard plus)
Controls			
Source	ScanHead Select, Gain, Filter, Sampling Resolution, AutoFind, Rotation Frequency, Record Mode	●	
Capture	Averaging, Rotation, Magnification, CW or Pulse Modes, Divergence, Gaussian Fit, Reference Position, Recompute	●	
Regions of Interest (ROI)	Single or Multiple, Automatic or Manual, Colors	●	
Profiles	Vertical Scale (1´, 10´, 100´), Logarithmic Scale, Z & PAN (Automatic or Manual)	●	
Computation: ISO 13694, ISO 11146	D_{slit}, (13.5%, 50% 2 User Selectable Clip Levels), $D_{4\sigma}$, Width ratios, Centroid Position, Peak Position, Centroid Separation, Peak Separation, Irradiance, Gaussian Fit, Ellipticity, Divergence, Total Power, Pulse Frequency, % power	●	
	Continuous, Rolling, Finite	●	
Pointing	Centroid or Peak, Accumulate Mode, Beam Indicator, Graph Center, Colors	●	
2D/3D	2D or 3D Mode, Linear or Logarithmic Scale, Resolution, Fill Contours, Solid Surface, or Wireframe, Clip Level Colors	●	
Charts	Chart Select, Parameter Select, Aperture Select, Update Rate, Start and Clear	●	
Logging	File Path/Name, Delimiter, Update Rate	●	
M^2	Rail Setup: Com Port and Length, Connect/Disconnect, Rail Control	●	
Views			
Profiles	Displays Beam Profiles for each axis, with optional Gaussian Overlays	●	
Results	Displays Values and Statistics for Selected results	●	
Pointing	Displays the XY position of the Centroid or Peak for each ROI , with optional overlays and Accumulate Mode	●	
Charts	Displays Time Charts for User-selected results	●	
2D/3D	Displays pseudo 2D/3D Beam Profile	●	
M^2 Wizard	An interactive procedure for measuring M2 by the Rayleigh Method	●	
File Saving			
NanoScan Data Files		●	
Text Files		●	
Data Logging			
Log to File		●	
Reports			
NanoScan Report		●	
Automation Interface			
ActiveX Automation Server			●
Minimum System Requirements			
PC computer running windows7 (32/64) Laptop or Desktop			
Core CPU 2GHz or better			
3GB of RAM or better			
1 USB 2.0 port			
At least 250MB free HDD space			
1440x900 Display Resolution or greater			
Add-in PCI/PCI-Express graphics card w/hardware acceleration			
DVD-ROM drive			

*Download the NanoScan Acquisition and Analysis Software Manual for a complete description of all Software Features

3.3.2 Beam Analysis

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Operating Space Charts

Operating Range is at Peak Sensitivity of Detector.
Operating Space is NOT absolute.
THESE CHARTS TO BE USED AS A GUIDE ONLY.

Power: Power in the measured laser beam. Assumes a round beam diameter. An elliptic beam can be approximated by using the maximum width dimension and assuming all the energy is in a beam of this diameter. For extremely elliptic beams (ratio >4:1)/ contact the factory. Applies to Si & GE detectors only.

Pulsed Operation (—————): Upper limit of the operating space for pulsed laser measurements.

Black Coating Removed (—————): Slits are blackened to reduce back reflections; blackening begins to vaporize near this line. Slits in pyrodetectors are not blackened.

Slit Damage (—————): Power density (watts/cm^2) where one can begin to cut the slits. Refer to Photon's Damage Threshold with High Power Laser Measurements document.

Left Boundary: Smallest beam size limited to 4-5 times the slit width. Some models have another limit due to electrical bandwidth.

Right Boundary: Instrument entrance aperture. The largest beam width (1/e^2) will be the aperture divided by 1.2-1.4.

Silicon Detector: Responsivity varies with wavelength. Detects between 190-950nm. Peak responsivity is 0.4 amps/watt at 850nm. Detector to detector responsivity variation can be as great as ±20%.

Silicon/25mm/25µm

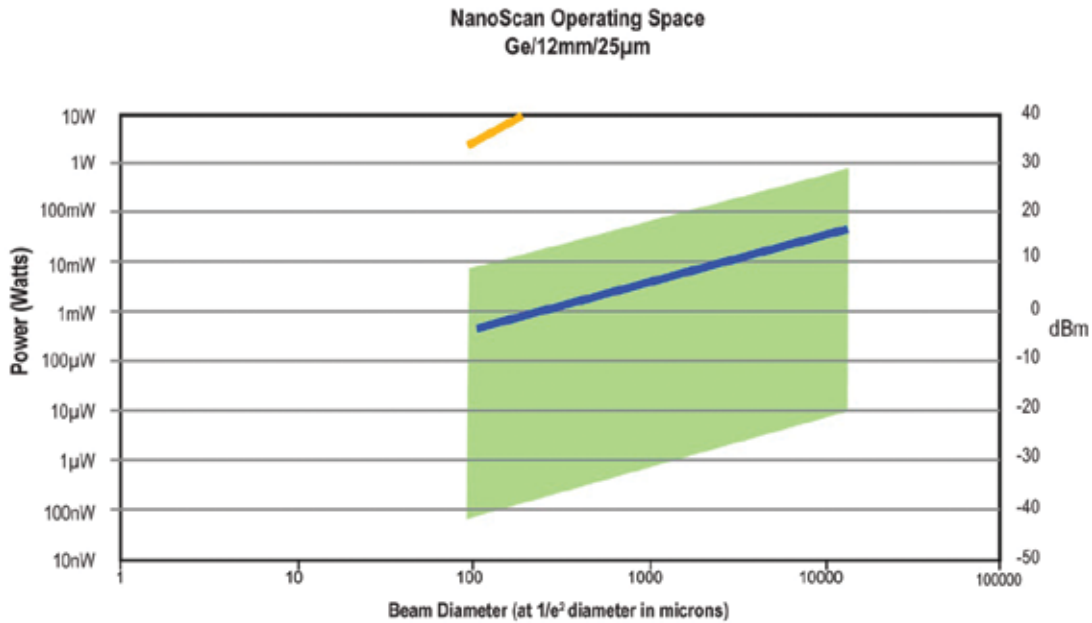NanoScan Operating Space
Si/25mm/25µm

3.3.2 Beam Analysis
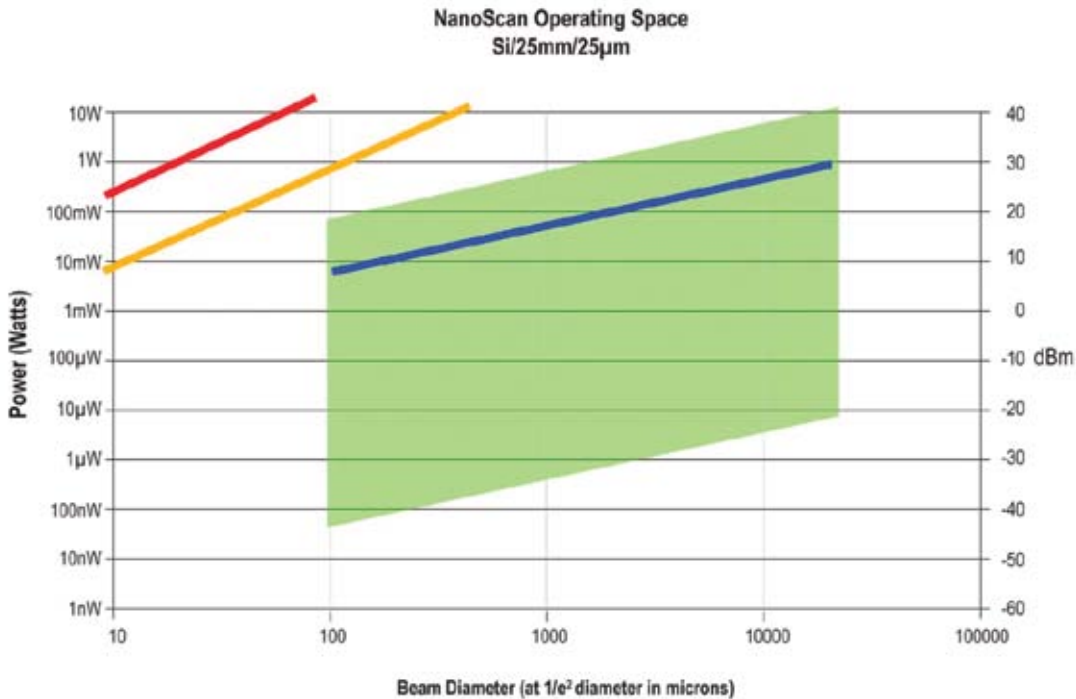
Germanium Detector

Responsivity: Detector conversion constant, incident photons to a current.
Detector: Responsivity varies with wavelength. Detects between 700-1800nm. Peak responsivity is 0.7 amps/watt at 1550nm. Detector to detector responsivity variation can be as great as ±20%.
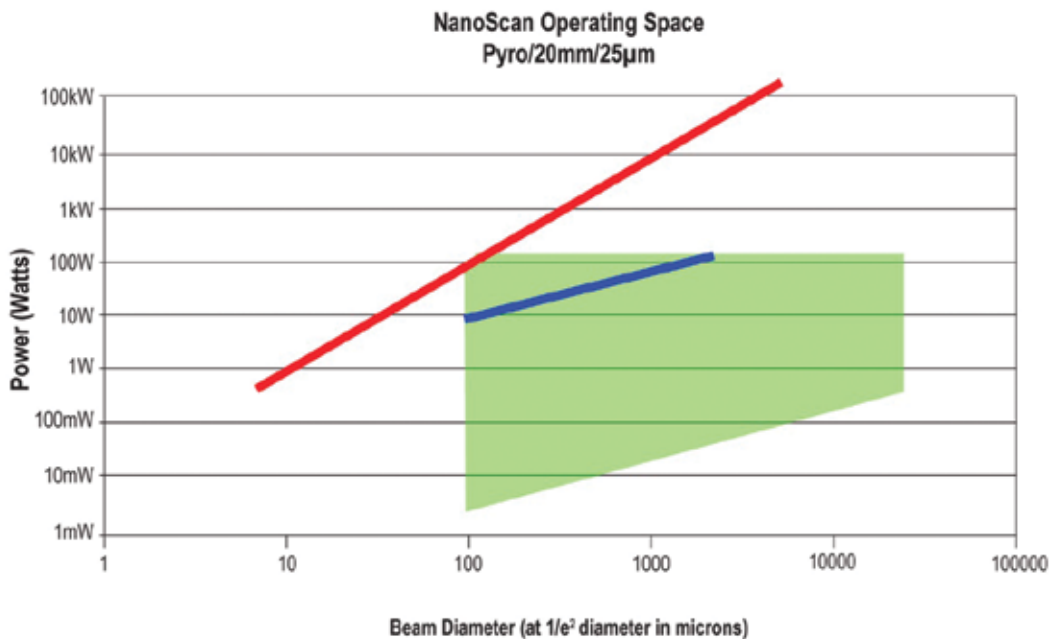
Germanium/12mm/25µm

Pyroelectric detector

Pyroelectric detector: Uniform in response between 0.2 and 20 microns wavelength.

Pyroelectric/20mm/25µm

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Ordering Information - NanoScan Systems

Both -STD & -PRO NanoScan Systems Include: NanoScan v2 Integrated Software package for use with NanoScan scanheads under Microsoft Windows operating systems.

ActiveX automation is provided in -PRO models.

Certificate of Calibration. Beam width is traceable to National Institute of Standards and Technology (NIST) to better than ±2% (NanoScan Pyroelectric detectors calibration to better than ±3%).

Item	Description	P/N
USB NS-Si/25/25-STD	NanoScan Si Detector 25mm aperture 25micron slits. High-resolution head featuring Si detector, 100mm diameter head with rotation mount, 25mm entrance aperture, and matched pair of 25.0micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength. USB	PH00390
USB NS-Si/25/25-PRO	Software includes automation feature. NanoScan Si Detector 25mm aperture 25micron slits. High-resolution head featuring Si detector, 100mm diameter head with rotation mount, 25mm entrance aperture, and matched pair of 25.0micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength. USB	PH00019
USB NS-Ge/12/25-STD	NanoScan Ge Detector 12.5mm Aperture 25micron slits. High-resolution head featuring Germanium detector, 100mm diameter head with rotation mount, 12.5mm entrance aperture, and matched pair of 25micron wide slits. USB	PH00395
USB NS-Ge/12/25-PRO	Software includes automation feature. NanoScan Ge Detector 12.5mm Aperture 25micron slits. High-resolution head featuring Germanium detector, 100mm diameter head with rotation mount, 12.5mm entrance aperture, and matched pair of 25micron wide slits. USB	PH00024
USB NS-PYRO/20/25-STD	NanoScan Large Area Pyroelectric Detector 20mm aperture 25micron slits. High-resolution head featuring pyroelectric detector, 100mm diameter head with rotation mount, 20mm entrance aperture, and matched pair of 25micron wide slits. Use for wavelengths from 190nm to >20micron. This model does not include a cooling fan. USB	PH00397
USB NS-PYRO/20/25-PRO	Software includes automation feature. NanoScan Large Area Pyroelectric Detector 20mm aperture 25micron slits. High-resolution head featuring pyroelectric detector, 100mm diameter head with rotation mount, 20mm entrance aperture, and matched pair of 25micron wide slits. Use for wavelengths from 190nm to >20micron. This model does not include a cooling fan. USB	PH00026
Software Upgrades		
NSv2 STD to NSv2 PRO Upgrade	Upgrade NanoScan v2 Standard version software to the PRO version. This upgrade opens the NanoScan automation feature for those users wanting to integrate or develop their own interface using Visual Basic for Applications to embed into such applications as LabView. Return scanhead to factory.	PH00417
NSv1 to NSv2 STD Upgrade	For those NanoScan users with pre v2 software (approx. before July 2012) they can upgrade their hardware to v2 STD capability and can run the new software. Automation capability is not available in v2 STD. Once upgraded the legacy software will run but the automation feature will be disabled in v2	PH00418
NSv1 to NSv2 PRO Upgrade	For those NanoScan users with pre v2 software (approx. before July 2012) they can upgrade their hardware to v2 PRO capability and can run the new software. Automation capability is included in v2 PRO. Once upgraded the legacy software will run including the automation capability in v2	PH00419
Legacy Software	Purchase the legacy V1.47 NanoScan software with licence and operations manual to –PRO scanheads to use the older software. (return scanhead to factory)	PH00420

NanoScan Options and Accessories

Item	Description	P/N
P200 Power Option	200mW (maximum power level) relative power meter option for Silicon or Germanium detector NanoScans. The /P200 provides better than 1.5% accuracy when calibrated against user's NIST traceable power meter and used in similar input geometry as calibrated.. Not applicable to Pyro-electric detector scan heads NOTE: P200 must be specified at time of purchase (Can be returned for upgrading)	PH00046

3.3.2 Beam Analysis

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