

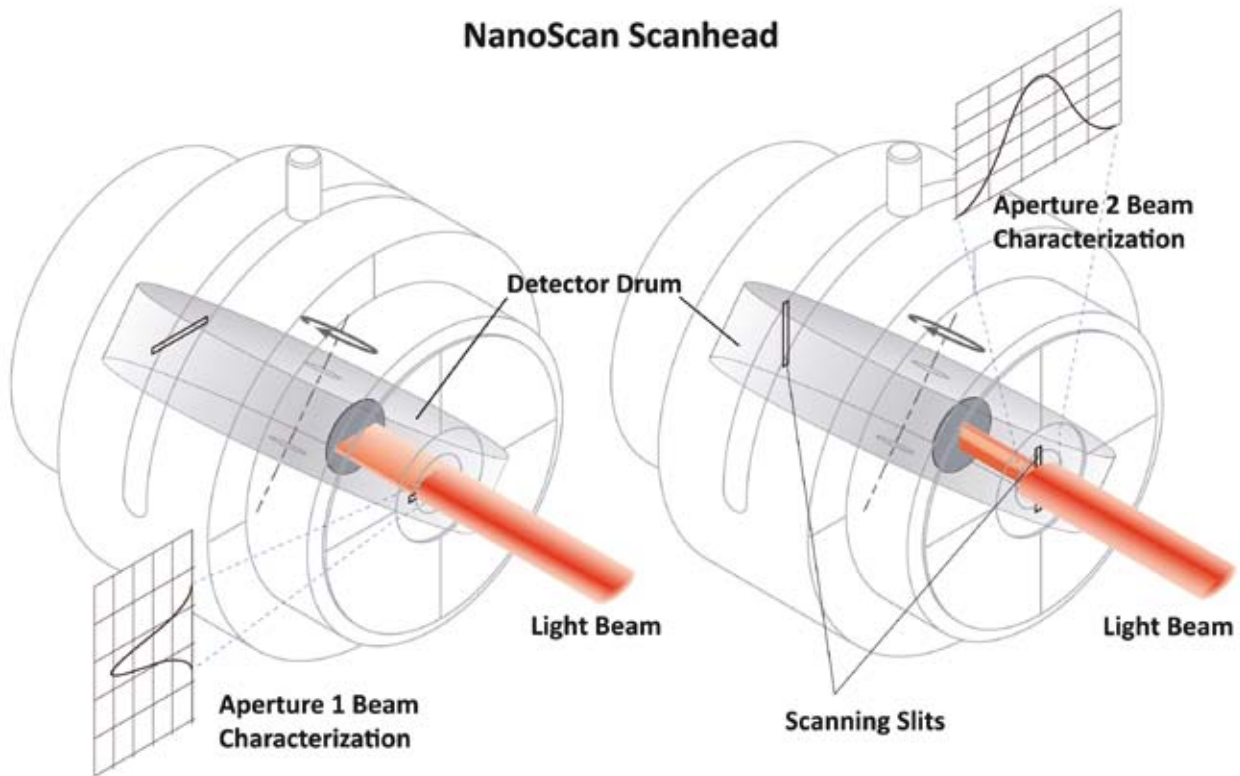
3.3 Introduction to Scanning-Slit Profilers

The scanning slit beam profiler moves a narrow slit in front of a photo-detector through the beam under analysis. Light passing through the slit onto the detector creates a photo-induced current in the detector. The slit acts as a physical attenuator in the scanning slit beam profiler, and the amplification gain on the detector can be set to avoid detector saturation for most beam profiling. A digital encoder precisely measures slit position. The photo-induced current is then plotted as a function of slit position to determine a linear profile of the beam. From this linear profile, important spatial information such as beam width, beam position, beam quality, and other characteristics are determined. This technique can accommodate a wide variety of test conditions.

Because slit scanners measure beams at high powers with little or no attenuation, they are ideal to profile beams used in material processing. Carbon dioxide (CO₂) lasers are widely used in materials processing, and have a 10.6 micron wavelength that cannot be profiled with most cameras. Slit scanners, therefore, provide a convenient means of measuring high-resolution CO₂ lasers with powers up to and exceeding 1000 watts.



NanoScan Scanhead



3.3.1 NanoScan

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.

Capabilities

The NanoScan digital controller, available with USB2 interface, operates with the latest Microsoft operating systems, including 64-bit Windows 7, and provides deep, 12-bit digitization of the signal for enhanced dynamic range up to 35dB power optical. 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 several hundred nanometers. 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 ability to alter the drum speed also helps to increase the dynamic range allowing a much larger operating space for any given scanhead (see operating space charts for a graphic explanation).

- 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 efficient code uses minimal computer resources allowing for smooth integration into automated test equipment via the ActiveX server.
- The Z-axis datum plane of the NanoScan is known to $\pm 25\mu\text{m}$ making the locating of beam waist position simple and accurate.
- Along with the ability to measure pulsed beams' 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 clean up noisy profiles.
- NanoScan software has built in capability to control a mechanical linear stage for automated measurement of beam caustic.
- Software has a built-in M^2 Wizard to assist in making manual propagation ratio measurements
- Time statistics allow any ISO beam parameter to be charted over time.
- ActiveX Automation commands included as standard in the software with samples of automation programs for Excel VBA, LabView and Visual Basic.net
- Data logging to files or COM ports available

*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.

Multiple Beam Analysis Software

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

Optional Power Meter

The silicon and germanium NanoScan systems offer the 200mW or the more accurate 75mW power meter as options. 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 P75 uses a more uniform Kodak Wratten filter that provides better than 1% accuracy, but it has an upper power limit of 75mW and must be supplied for a specific wavelength of use.

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 due to the broad range of power levels and wavelengths encountered with these scanheads.

M^2 Wizard

M^2 -squared (M^2) software Wizard is included in NanoScan Analysis and Acquisition Software 1.2 and above, and is discussed in the M^2 section of the catalog.

Available Detectors

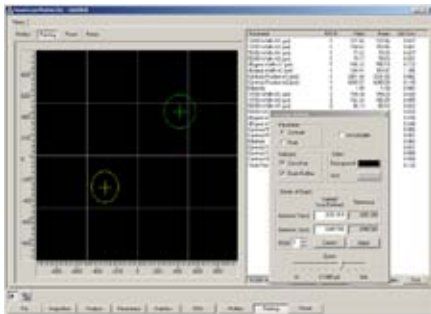
The NanoScan is available with silicon, germanium and pyroelectric detectors to cover the light spectrum from UV to far infrared beyond 100 μ m. The scanheads are available in several sizes, apertures and slit dimensions.

Features

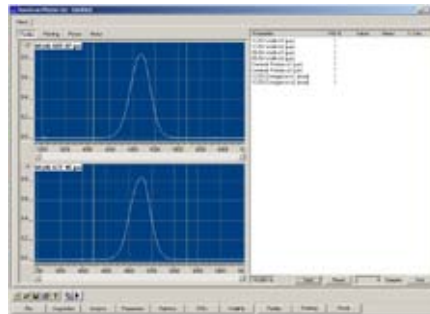
- Sub-micron precision for position and beam size
- Easy-to-use integrated software package
- Single and multiple beam analysis standard in one software package
- Software controllable scan speed (update rate)
- Peak-connect algorithm for pulsed beam measurement
- USB2 interface and digital head control
- 12-bit digitization of signal
- ActiveX automation for communication with other software packages
- Optional power meter with silicon and germanium scanheads
- Silicon, germanium, and pyroelectric detectors available

Benefits

- Laser beam XY position measurement uncertainty better than 300nm
- Beam size measurement precision to better than 0.5%
- High dynamic range ($\sim 35\text{dB}_{\text{power}}$)
- Low instrument noise/jitter
- Precise knowledge of components' beam configuration possible to allow precise component assembly
- OEM automation integration capability
- Simple, intuitive software GUI for minimal learning curve
- Flexibility to control more head parameters increases range of operation
- Low-power pulsed beams can be measured
- Many high-power beams can be measured at focus without attenuation



NanoScan Pointing Screen



NanoScan Dual Profile and Statistics



Power Window

NanoScan Configurations

Detector Type	Power Range	Wavelength	Aperture	Slits	Scanhead Size
Silicon	$\sim 100\text{nW} \sim 100\text{mW}$	190nm-1000nm	3.5mm	1.8 μm 1.0 μm	63mm
			9mm	5 μm 25 μm	63mm
			25mm	25 μm	100mm
Germanium	$\sim 1\mu\text{W} \sim 100\text{mW}$	700nm-1800nm	3.5mm	1.8 μm 1.0 μm	63mm
			9mm	5 μm 25 μm	63mm
			25mm	25 μm	100mm
Pyroelectric	100mW-100W	190nm- >100 μm	9mm	5 μm	63mm

3.3.1.1 Measuring Pulsed Beams with a Slit-based Profiler

Pulse Rates, Power, and Damage Considerations

Although the NanoScan was designed originally to measure continuous wave (CW) laser beams, many lasers are operated in the pulsed mode. Measuring these pulsed beams has generally required the use of a CCD array profiler. This is a reasonable solution for low power lasers in the UV and visible wavelength range, but these will require external attenuation. Once the lasers leave the UV-VIS range, array cameras become extremely expensive. Although low frequency pulsed lasers operating in the 1Hz to 1000Hz range have no real alternative to the array profiler, the NanoScan can measure kHz frequency lasers. The NanoScan profiler incorporates the “peak connect” algorithm and software-controlled variable scan speed on all scanheads to enable the measurement of these pulsed lasers. It also measures the actual pulse repetition rate in order to improve the performance of the peak connect algorithm. 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 is well suited to measure them, too. We will discuss the measurement of all these types of pulsed lasers below.

PWM Lasers

Many lasers, especially CO₂ lasers, use pulse width modulation (PWM) to control the power level of the laser. This is not true, pulsed operation, but rather a reduction of the duty cycle to lower the average power. The beam operates as if it were CW, and many operators do not even realize that the laser is pulsing. However, when attempting to measure a PWM laser with a scanning slit profiler, it must be treated as a pulsed laser source. To use the pulsed mode of the NanoScan the laser’s pulse frequency must be at least several kHz, and the combination of the frequency and beam size must provide a sufficient number of pulses across the beam to generate a meaningful profile. 15 pulses are a reasonable minimum. PWM lasers usually operate around 10kHz. The relationship of the beam size and frequency is a fairly simple mathematical model. The NanoScan drum speed is software controlled from 1.25Hz to 20Hz. There are two available drum sizes for the NanoScan; the standard head has a drum diameter of 42mm and the large aperture and high power heads use a larger drum with 84mm diameter. On the 42mm drum at the 1.25Hz rotation rate the slits travel at around 116.6mm per second or 116.6μm per millisecond. At a 10kHz laser repetition rate, a 175μm beam would have 15 pulses during the time that the slit was traversing it. This would provide enough data to generate a meaningful profile. A smaller beam would require a faster pulse rate, a larger one could perhaps run at a lower repetition rate. For example, a 1.0mm beam could be measured with a pulse rate as low as 2kHz and still provide a profile.

There is a table of minimum beam sizes and pulse frequencies for the large and small hubs and scan speeds at the end of this document. It is recommended that the 1.25Hz scan speed be used for pulsed beams, however, if the beam sizes are large enough, or the pulse rates fast enough, the measurement can be sped up by increasing the scan speed to 2.5Hz or above. The NanoScan software will generate a warning if the scan rate is set too high for the pulse rate or beam size. This warning algorithm is based on having at least 15 pulses across the beam to provide a minimum of 2% accuracy.

Q-Switched Lasers

Another type of pulsed laser, operating in the kHz pulse rate regime is the Q-Switched laser. These lasers use the pulsing to increase, rather than decrease, their effective power. By concentrating the laser power into a short pulse, the peak power of each pulse increases while maintaining a low average power. In order to measure these lasers the same mathematical relationship of pulse rate to beam diameter applies, but there is an additional complication; the peak power of the pulses may exceed the damage thresholds of the NanoScan even though the average power remains within the operating space. CW beams are measured as power (P) in Watts; pulsed beams as energy (E) in Joules. Therefore it is necessary to understand the beam’s energy (E_{pulse}) to determine whether the unattenuated beam can be directly measured with the NanoScan.

$$E_{pulse} = \frac{P_{avg}}{f_{laser}}$$

Therefore a beam with an average power of 300 Watts with a pulse frequency of 8kHz will have energy as follows:

$$E_{pulse} = \frac{P_{avg}}{f_{laser}} = \frac{300W}{8 \times 10^3 Hz} = 37.5mJ$$

The power density per pulse is also a function of the pulse duration τ . This is also important in understanding the potential damage to the profiler. Taking the above example, if the pulse duration is 1ms, then:

$$P_{pulse} = \frac{E_{pulse}}{\tau} \equiv \frac{37.5mJ}{1 \times 10^{-3}s} = 37.5W$$

Pico- and Femtosecond Lasers

When the pulse duration of the laser gets very short, such as with pico- and femtosecond lasers, the peak power of the pulses can become very large. This creates some added complications when determining the type of scanhead that can safely measure these beams. In addition to the average power of the beam, which is used to determine the proper operating space of a given scan head, it is important to know the energy density of the pulses. The energy density must be below the damage threshold for the aperture material, and the average power must fall within the operating space of the scan head for it to be possible to measure the beam without additional attenuation. To determine the energy density first use the above formula for the E_{pulse} :

$$E_{pulse} = \frac{P_{avg}}{f_{laser}}$$

Most pico- and femtosecond lasers have both a high repetition rate and a fairly low average power. They use the short pulse duration to amplify the effective power of the laser beam. A typical laser that one might encounter would have an average power of 1.0 watt and a repetition rate of 80kHz. For this laser the E_{pulse} would be:

$$E_{pulse} = \frac{P_{avg}}{f_{laser}} = \frac{1W}{80000sec^{-1}} = 12.5\mu J$$

Using this value calculate the energy density for a given beam diameter by the following formula. Note that the energy density is presented as J/cm²; therefore the beam area needs to be converted to cm in the formula. Unless the beam is wildly different from round, it is easiest to consider that the area will be that of a circle:

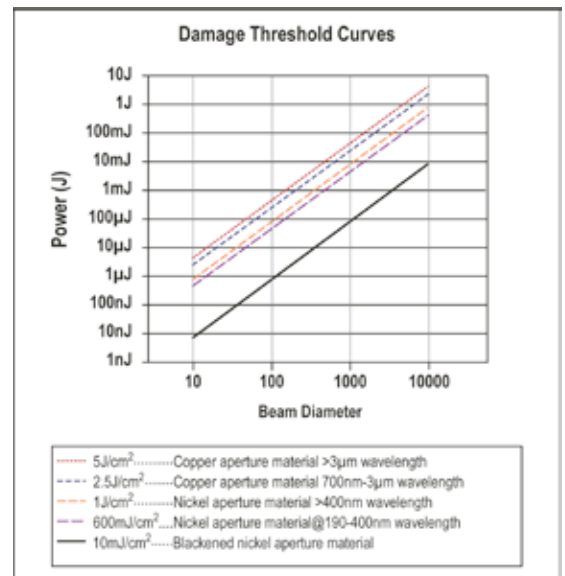
$$E_{density} = \frac{E_{pulse}}{\pi r^2}$$

For a 100 μ m beam at the 12.5 μ J:

$$E_{density} = \frac{12.5\mu J}{\left(\frac{100\mu m \times 0.0001}{2}\right)^2 \pi} = 0.16J/cm^2 = 160mJ/cm^2$$

Once the energy density is calculated, it can be compared to the damage threshold for the aperture type and the wavelength range for the aperture material. The standard blackened slit material can only handle 10mJ/cm² before the blackening starts to ablate. For this reason, scan heads intended for use with these pico- and femtosecond lasers should have the reflective slits, regardless of the detector type or the average power of the lasers. The wavelength of the laser also influences the energy density that the aperture material can withstand. For the standard nickel alloy slits the maximum energy density is 600mJ/cm² for the range of 190nm to 400nm; for 400nm and above the value is 1.0J/cm². For the high power copper slits the values are 2.5J/cm² from 700nm to 3 μ m wavelength and 5J/cm² above 3 μ m. Copper slits are not recommended for use below 700nm.

The chart below can be used in lieu of the calculation to compare the energy per pulse at a given beam diameter with the appropriate threshold line for the aperture material and wavelength of use. For the above case the 12.5 μ J energy at 100 μ m would be below the 600mJ damage line, but would certainly be well above the damage level for blackened apertures.



Minimum Beam Size per Pulse Frequency

NanoScan	Normal Drum					Large Drum (HP)			
Rotation Rate (Hz)	1.25	2.50	5.00	10.00	20	1.25	2.50	5.00	10.00
Slit Speed (µm/msec)	116.63	233.25	466.50	933.01	1866.01	233.25	466.50	933.01	1866.01
Data Points per Profile	15	15	15	15	15	15	15	15	15
Pulse Frequency (kHz)	Minimum Beam Diameter in µm					Minimum Beam Diameter in µm			
0.5	3499	6998	N/A	N/A	N/A	6998	13995	N/A	N/A
1	1749	3499	6998	N/A	N/A	3499	6998	13995	N/A
2	875	1749	3499	6998	N/A	1749	3499	6998	13995
3	583	1166	2333	4665	N/A	1166	2333	4665	9330
4	437	875	1749	3499	6998	875	1749	3499	6998
5	350	700	1400	2799	5598	700	1400	2799	5598
6	292	583	1166	2333	4665	583	1166	2333	4665
7	250	500	1000	1999	3999	500	1000	1999	3999
8	219	437	875	1749	3499	437	875	1749	3499
9	194	389	778	1555	3110	389	778	1555	3110
10	175	350	700	1400	2799	350	700	1400	2799
11	159	318	636	1272	2545	318	636	1272	2545
12	146	292	583	1166	2333	292	583	1166	2333
13	135	269	538	1077	2153	269	538	1077	2153
14	125	250	500	1000	1999	250	500	1000	1999
15	117	233	467	933	1866	233	467	933	1866
16	109	219	437	875	1749	219	437	875	1749
17	103	206	412	823	1646	206	412	823	1646
18	97	194	389	778	1555	194	389	778	1555
19	92	184	368	737	1473	184	368	737	1473
20	87	175	350	700	1400	175	350	700	1400
21	83	167	333	666	1333	167	333	666	1333
22	80	159	318	636	1272	159	318	636	1272
23	76	152	304	608	1217	152	304	608	1217
24	73	146	292	583	1166	146	292	583	1166
25	70	140	280	560	1120	140	280	560	1120
50	35	70	140	280	560	70	140	280	560
100	17	35	70	140	280	35	70	140	280
150	12	23	47	93	187	23	47	93	187

Collimation

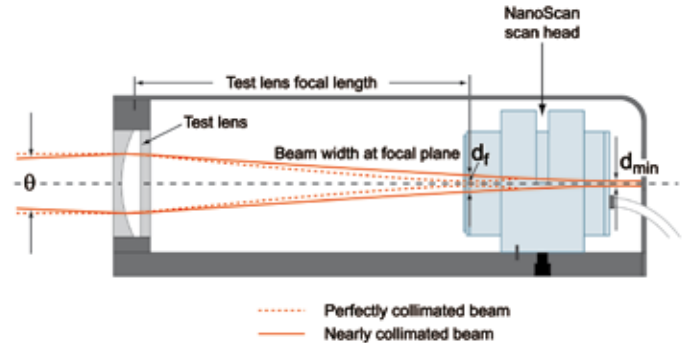
A single beam size measurement using a Collimation Fixture is all that is required to determine laser beam collimation, greatly simplifying this measurement. Real-time optical alignment can then be performed to determine best collimation. No special training is needed to perform these simple measurements. Unlike with most measurement shortcuts, high-precision collimation measurements can be performed with exceedingly high resolution, higher than alternative techniques. All that is required for these accurate measurements of collimation is a test lens and a NanoScan. The laser beam profiler is positioned such that it measures beam size at the geometric focus of the lens. From lens theory, the angle of collimation is determined by the equation: $q = Df / f$, where q is the angle of collimation, Df is the beam size measured at the focal length, and f is the focal length of the lens. Once the beam size is measured at the focal length of the lens, simply dividing this measured beam size by the divergence angle determines the laser beam collimation angle. The beam profiler remains fixed, and active alignment is easily performed in real time. This level of simplicity, speed, and functionality is simply not possible with techniques involving multiple beam profile positions.

Collimation Fixtures

Divergence/Collimation test fixtures based on a high quality test lens to focus your collimated or diverging beam.

Fixtures require a complete NanoScan System.

COL-FXT 250	Nominal 250mm focal length lens. Includes an enclosure to block stray light
COL-FXT 250 TEL	Nominal 250mm focal length lens. For wavelengths of use at 1310 or 1550nm with lens repositioning. Includes an enclosure to block stray light
COL-FXT 500 MIR	For wavelengths of use at 3–5 μ m.
COL-FXT C02	Zinc selenide (ZnSe) lens with a focal length of 190.5mm. For wavelength of use at 10.6 μ m. Includes an enclosure that holds an adjustable entrance iris. Requires a Pyro NanoScan System.



Rayleigh Range Translation Test Fixture for NanoScan

Photon Inc.'s Rayleigh Range Translation Test Fixture (RAL-FXT) provides convenient translation of a NanoScan scanhead assembly and a digital readout of its relative position along the beam axis. Used with a user-provided focusing lens and the M² Wizard in the NanoScan Analysis Software, this fixture offers a quick and easy method to determine the times-diffraction propagation factor (M²) of a laser.

The RAL-FXT features a base plate, sliding carriage and digital micrometer. The base plate (5.4x10.2x0.38in.) provides a series of 1/4-20 threaded mounting holes at 2in. centers to facilitate convenient fixturing of the assembly with respect to the focusing lens. The sliding carriage accommodates the combination of the 0.125-in. dowel pin and the 1/4-20 mounting hole found on any Photon scan head's rotation mount, and enables smooth movement of the scan head assembly over a 6-in. range of travel. A Mitutoyo micrometer with a handy re-zeroing feature and accompanying slide provides precise determination of the scan head location and/or travel distance with a resolution of tens of microns.



Ordering Information - NanoScan Systems

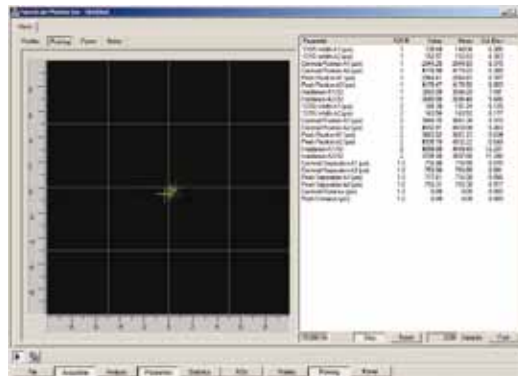
All NanoScan Systems Include: NanoScan Integrated Software package. Beam Analysis Software for use with NanoScan scanheads under Microsoft Windows operating systems.

Includes single and multiple beam analysis capability, and ActiveX automation.

Measurements include: Spot size, position and position difference information.

Includes a targeting screen for position adjustment with $1/e^2$ contours plotted.

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



Accumulated Pointing Window

Item	Description	P/N
USB NS-Si/3.5/1.8	NanoScan Silicon Detector 3.5mm aperture 1.8micron slits. High-resolution head featuring Silicon detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength. USB	PH00015
USB NS-Si/3.5/1.0	NanoScan Silicon Detector 3.5mm aperture 1.0micron slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.0micron wide slits. Use from 190nm to wavelengths <1micron Not for 1.06micron wavelength. USB	PH00016
USB NS-Si/9/25	NanoScan Si Detector 9mm aperture 25micron slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25.0micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength. USB	PH00017
USB NS-Si/9/5	NanoScan Si Detector 9mm aperture 5micron slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5.0micron wide slits. Use from 190nm to wavelengths <1micron. Not for 1.06micron wavelength. USB	PH00018
USB NS-Si/25/25	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/3.5/1.8	NanoScan Ge Detector 3.5mm aperture 1.8micron slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8micron wide slits. Use from 700nm to 1.8micron wavelength. USB	PH00020
USB NS-Ge/3.5/1.0	NanoScan Ge Detector 3.5mm Aperture 1.0micron slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.0micron wide slits. Use from 700nm to 1.8micron wavelength. USB	PH00021
USB NS-Ge/9/25	NanoScan Ge Detector 9mm Aperture 25micron slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25micron wide slits. Use from 700nm to 1.8micron wavelength. USB	PH00022
USB NS-Ge/9/5	NanoScan Ge Detector 9mm Aperture 5.0micron slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5.0micron wide slits. Use from 700nm to 1.8micron wavelength. USB	PH00023
USB NS-Ge/12/25	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
NS-USB	NanoScan USB Controller /NS USB	PH00030
NH NS-Si/3.5/1.8	Head only NanoScan-Si 3.5mm aperture 1.8 μ m slits	PH00031
NH NS-Si/3.5/1.0	Head only NanoScan-Si 3.5mm aperture 1.0 μ m slits	PH00032
NH NS-Si/9/25	Head only NanoScan-Si 9mm aperture 25 μ m slits	PH00033
NH NS-Si/9/5	Head only NanoScan-Si 9mm aperture 5 μ m slits	PH00034
NH NS-Si/25/25	Head only NanoScan-Si 25mm aperture 25 μ m slits	PH00035
NH NS-Ge/3.5/1.8	Head only NanoScan-Ge 3.5mm aperture 1.8 μ m slits	PH00036
NH NS-Ge/3.5/1.0	Head only NanoScan-Ge 3.5mm aperture 1.0 μ m slits	PH00037
NH NS-Ge/9/25	Head only NanoScan-Ge 9mm aperture 25 μ m slits	PH00038
NH NS-Ge/9/5	Head only NanoScan-Ge 9mm aperture 5 μ m slits	PH00039
NH NS-Ge/12/25	Head only NanoScan-Ge 12mm aperture 25 μ m slits	PH00040
P200		PH00046



NanoScan Option NSEC: Side exit cable

NanoScan Options and Accessories

Item	Description	P/N
NSEC	Side exit cable option for NanoScan	PH00252
Cable-x	Custom NanoScan cable-length x	PH00049
NS-YE	Extension NanoScan cable 3m	PH00050
C-Mnt	C-Mount attachment for NS	PH00051
NS Upgrade	NS Software upgrade	PH00054
COL-FXT 250	250 mm FL collimation fixture	PH00070
COL-FXT 250 TEL-X	250 mm FL collimation fixture 1550nm	PH00071
COL-FXT CO ₂	Collimation Fixture for 10.6μmWL	PH00072
RAL-FXT	Rayleigh fixture for manual M ²	PH00073
RSP100	RailScan motion stage 100mm length	PH00078
RSP200	RailScan motion stage 200mm length	PH00079
RSP500	RailScan motion stage 500mm length	PH00080
H-I LA	Modify H-I for Large (100mm) Scan head	PH00082
H-I 980-VIS w/lens	NS lens mount bracket and 60X lens 980 WL	PH00146
H-I 1550 w/ lens	NS lens mount bracket and 40X lens 1550 WL	PH00081
H-I High energy IR	NS lens mount bracket w/ high energy lens WLxxx	PH00147
H-I 100X	NS lens mount bracket and 100X lens WLxxx	PH00148
3180	Desktop PC computer operating MS windows loaded with appropriate Photon software	PH00087

Power attenuation options

Item	Description	P/N
HP-ND1 350 thru 399nm	Must be ordered w/new system – Si & Ge only	PH00370
HP-ND1 400 thru 700nm	Must be ordered w/new system – Si & Ge only	PH00371
HP-ND2 400 thru 700nm	Must be ordered w/new system – Si & Ge only	PH00372
HP-ND3 400 thru 700nm	Must be ordered w/new system – Si & Ge only	PH00373
HP-ND1 750 thru 890nm	Must be ordered w/new system – Si & Ge only	PH00374
HP-ND2 750 thru 890nm	Must be ordered w/new system – Si & Ge only	PH00375
HP-ND3 750 thru 890nm	Must be ordered w/new system – Si & Ge only	PH00376
HP-ND1 900 thru 1100nm	Must be ordered w/new system – Si & Ge only	PH00377
HP-ND2 900 thru 1100nm	Must be ordered w/new system – Si & Ge only	PH00378
HP-ND3 900 thru 1100nm	Must be ordered w/new system – Si & Ge only	PH00379
HP-ND1 1150 thru 1600nm	Must be ordered w/new system – Si & Ge only	PH00380
HP-ND2 1150 thru 1600nm	Must be ordered w/new system – Si & Ge only	PH00381
HP-ND3 1150 thru 1600nm	Must be ordered w/new system – Si & Ge only	PH00382