QE65000 Spectrometer

Scientific-Grade Spectroscopy in a Small Footprint

QE65000

The QE65000 Spectrometer is the most sensitive spectrometer we've developed. Its Hamamatsu FFT-CCD detector provides 90% quantum efficiency as well as superior signal-to-noise ratio and signal processing speed.

QE65000's onboard programmable microcontroller puts you in command of the spectrometer and its accessories and provides 10 user-programmable digital inputs/outputs as well as a pulse generator for triggering other devices.

The QE65000's great quantum efficiency is not its only distinguishing feature. Its 2D area detector lets us bin (or sum) a vertical row of pixels. That offers significant improvement in the signal-to-noise ratio (>1000:1) performance and signal processing speed of the detector compared with a linear CCD, where signals are digitally added by an external circuit.

Because the QE65000's detector is back-thinned, it has outstanding native response in the UV. It's an excellent option for low light-level applications such as fluorescence, Raman spectroscopy, DNA sequencing, astronomy and thin-film reflectivity. Its TE-cooled detector features low noise and low dark signal, enabling low light-level detection and long integration times from 8 ms to 15 minutes.

Features

- Onboard programming
- Multiple interface and bench options
- Quantum efficiency of 90%
- Ideal for low light level applications

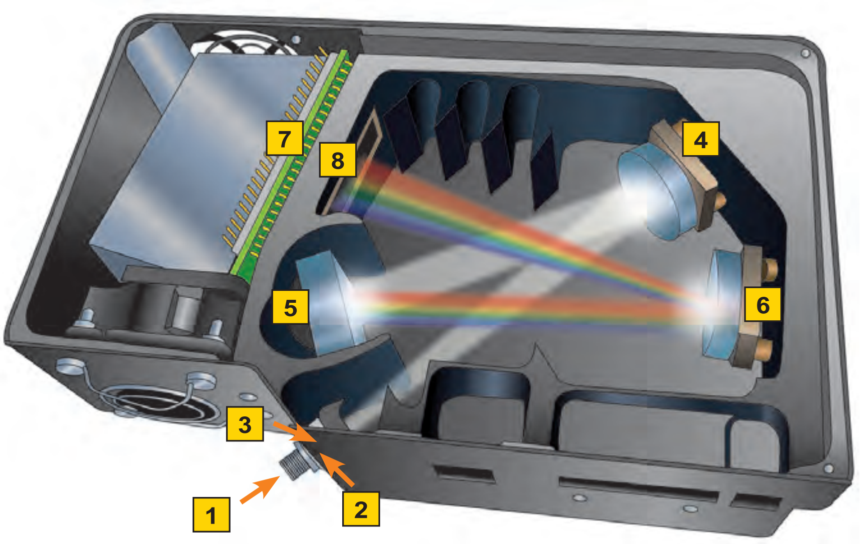
Physical	
Dimensions:	182 mm x 110 mm x 47 mm
Weight:	1.18 kg (without power supply)
Detector	
Detector:	Hamamatsu S7031-1006
Detector range:	200-1100 nm
Pixels:	1024 x 58 (1044 x 64 total pixels)
Pixel size:	24 μm^2
Pixel well depth:	300,000 electrons/well, 1.5 m elec/column
Sensitivity:	22 electrons/count all λ; 26 photons/count @ 250 nm
Quantum efficiency:	90% peak; 65% at 250 nm
Optical Bench	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and output
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits or fiber (no slit)
Grating options:	Multiple grating options, UV through Shortwave NIR
HC-1 grating:	Provides 200-1050 nm range (best efficiency)
OFLV filter options:	OFLV-QE (200-950 nm); OFLV-QE-250 (250-1000 nm); OFLV-QE-300 (300-1050 nm); OFLV-QE-350 (350-1100 nm); OFLV-QE-400 (400-1150 nm)
Other filter options:	Longpass OF-1 filters
Fiber optic connector:	SMA 905 to 0.22 NA single-strand optical fiber
Spectroscopic	
Wavelength range:	Grating dependent
Optical resolution:	~0.14-7.7 nm (FWHM) (slit dependent)
Signal-to-noise ratio:	1000:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	3 RMS counts
Dynamic range:	7.5 x 10^9 (system), 25000:1 for a single acquisition
Integration time:	8 ms-15 minutes
Stray light:	<0.08% at 600 nm; 0.4% at 435 nm
Corrected linearity:	>99%
Electronics	
Power consumption:	500 mA @ 5 VDC (no TE cooling); 3.5 A @ 5 VDC (with TE cooling)
Data transfer speed:	Full scans to memory every 8 ms with USB 2.0 port, 18 ms with USB1.1 port, 300 ms with serial port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs (general purpose inputs/outputs)
Breakout box:	Yes, HR4-BREAKOUT
Trigger modes:	4 modes
Gated delay feature:	Yes
Connector:	30-pin connector
Power-up time:	<5 seconds
Dark current:	4000 e-/pixel/sec @ 25 °C; 200 e-/pixel/sec @ 0 °C
Temperature and Thermoelectric (TE) Cooling	
Temperature limits:	0 °C to 50.0 °C; no condensation
Set point:	Lowest set point is 40 °C below ambient
Stability:	+/-0.1 °C of set temperature in <2 minutes

QE65000 and Maya2000 Pro Spectrometers

Optimizing QE65000 and Maya2000 Pro Spectrometers for Your Application

Our high-sensitivity back-thinned 2D FFT-CCD spectrometers for low light-level, UV-sensitivity and other scientific applications are available in several versatile options: an improved version of our thermoelectrically cooled QE65000 Spectrometer, distinguished by improved stray light and low noise characteristics; and the uncooled Maya2000 Pro®, which offers greater than 75% quantum efficiency, high dynamic range and excellent UV response.

QE65000 and Maya2000 Pro optical bench options are described below. Although the bench diagram is specific to the QE65000, the optical design is nearly identical to the Maya2000 Pro. The primary differences are the detector and thermoelectric cooler.



1 SMA 905 Connector
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbance filter and fiber clad mode aperture.

2 Fixed Entrance Slit: specify slit size
Light passes through the installed slit, which acts as the entrance aperture. Slits are available in widths from 5 µm to 200 µm. Each is permanently fixed to the SMA 905 bulkhead. (Without a slit, a fiber acts as the entrance aperture.)

3 Longpass Absorbing Filter: optional
If selected, an OF-1 absorbing filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to limit bandwidth of light entering the spectrometer.

4 Collimating Mirror: specify standard or SAG+
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. Opt to install a standard mirror or a SAG+UPG-HR mirror.

5 Grating: specify grating
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 Focusing Mirror: specify standard or SAG+
This mirror focuses first-order spectra on the detector plane and sends higher orders to light traps built into the optical bench. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. Opt for a standard mirror or a UV-absorbing SAG+UPG-HR mirror.

7 Detector with TE cooling
The TE-cooled, back-thinned, "2D" detector provides great signal processing speed, improved signal-to-noise ratio and great native response in the UV. It generates virtually no dark noise, allowing for long integration times.

8 OFLV Filters: optional
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

Technical Tip

In a typical symmetrical crossed Czerny-Turner optical design, there are two mirrors that help move light around the optical bench on its way to the detector: the collimating mirror (first mirror), which makes parallel the light entering the bench and then reflects that light onto the grating; and the focusing (second) mirror, which focuses the light onto the detector plane.

The SAG+ mirrors we use were developed by our sister company Ocean Thin Films. These silver-coated mirrors have very high reflection values – >97% across Visible and near infrared wavelengths. What's more, they absorb nearly all UV light, a characteristic that reduces the effects of excitation scattering in fluorescence measurements.

QE65000 and Maya2000 Pro Spectrometers

Bench Accessories for Your High-sensitivity Spectrometers

SMA 905 Connector

This precision connector aligns to the spectrometer's entrance slit and ensures concentricity of the fiber. While SMA 905 is standard, connector adapters are available for mating to ST or FC connectors.

Fixed Entrance Slits

One option available with the user-configured spectrometer is the size of the entrance aperture, with the width determining the amount of light entering the bench. A slit is fixed in place; it only can be changed by our technicians.

Slit	Description	QE Pixel Resolution	Maya Pixel Resolution
SLIT-5	5-µm wide x 1-mm high	~2.0 pixels	~1.5 pixels
SLIT-10	10-µm wide x 1-mm high	~2.2 pixels	~2.0 pixels
SLIT-25	25-µm wide x 1-mm high	~2.6 pixels	~2.5 pixels
SLIT-50	50-µm wide x 1-mm high	~3.3 pixels	~4.2 pixels
SLIT-100	100-µm wide x 1-mm high	~4.7 pixels	~8.0 pixels
SLIT-200	200-µm wide x 1-mm high	~8.9 pixels	~15.3 pixels

Longpass Absorbing Filter

We offer longpass absorbing or blocking filters; each filter has a transmission band and a blocking band to restrict radiation to a certain wavelength region for eliminating second- and third-order effects. These filters are installed permanently between the slit and the clad mode aperture in the bulkhead of the SMA 905 Connector.

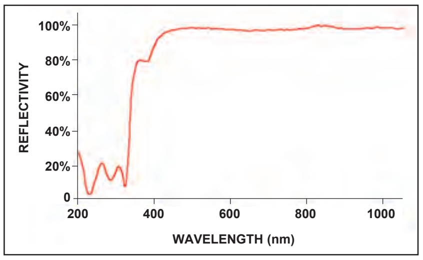
Item	Description
OF1-WG305	Longpass filter; transmits light >305 nm
OF1-GG375	Longpass filter; transmits light >375 nm
OF1-GG395	Longpass filter; transmits light >395 nm
OF1-GG475	Longpass filter; transmits light >475 nm
OF1-OG515	Longpass filter; transmits light >515 nm
OF1-OG550	Longpass filter; transmits light >550 nm
OF1-OG590	Longpass filter; transmits light >590 nm

Collimating and Focusing Mirrors

You can replace the standard aluminum-coated reflective mirrors with our proprietary, UV-absorbing SAG+ Mirrors, which increase reflectance in the VIS-NIR and, in turn, increase the sensitivity of the spectrometer. SAG+ Mirrors are often specified for fluorescence. These mirrors also absorb nearly all UV light, which reduces the effects of excitation scattering in fluorescence measurements. Unlike most silver-coated mirrors, the SAG+ mirrors won't oxidize.

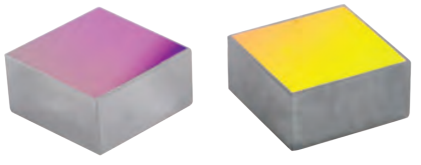
Item Code: SAG+UPG-HR

SAG+ Mirror Reflectivity



Grating and Wavelength Range

With a choice of multiple gratings, you can easily customize the spectral range and most efficient region of your QE65000 or Maya2000 Pro Spectrometer. Our gratings are permanently fixed in place at the time of manufacture and are available in both ruled and holographic versions. See pages 44-47 for grating options and efficiency curves and consult an Ocean Optics Applications Scientist for details.

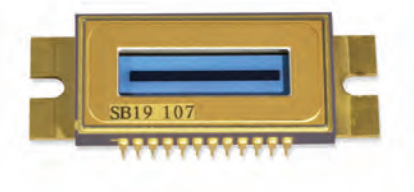


QE65000 and Maya2000 Pro Spectrometers

Detectors and Accessories for Your High-sensitivity Spectrometers

Back-thinned Area Detectors

The Hamamatsu FFT-CCD detectors used in the QE65000 and Maya2000 Pro have great UV response and provide up to 90% quantum efficiency (defined as how efficiently a photon is converted to a photo-electron). The QE65000 uses the S7031-1006 2D array detector and the Maya2000 Pro uses the S10420 detector. Each detector is responsive from 200-1100 nm.



Detectors with OFLV Filters

OFLV Variable Longpass Order-sorting Filters are applied to the detector's window to eliminate second- and third-order effects. We use a patented coating technology to apply the filter to the substrate.

QE65000 Detector Options

Item	Description
DET-QE	Hamamatsu S7031 detector, installed, w/no variable longpass filter
DET-QE-OFLV-200	Hamamatsu S7031 detector, installed, w/OFLV-QE-200 variable longpass filter
DET-QE-OFLV-250	Hamamatsu S7031 detector, installed, w/OFLV-QE-250 variable longpass filter
DET-QE-OFLV-300	Hamamatsu S7031 detector, installed, w/OFLV-QE-300 variable longpass filter
DET-QE-OFLV-350	Hamamatsu S7031 detector, installed, w/OFLV-QE-350 variable longpass filter
DET-QE-OFLV-400	Hamamatsu S7031 detector, installed, w/OFLV-QE-400 variable longpass filter
DET-QE-WINDOWLESS	Hamamatsu S7031 detector, installed, with no window options; required for VUV applications

Maya2000 Pro Detector Options

Item	Description	Spectrometer
DET-MAYAPRO	Hamamatsu S10420 detector, installed, w/no variable longpass filter	Maya2000 Pro
DET-MAYAPRO-OFLV-200	Hamamatsu S10420 detector, installed, w/OFLV-200 variable longpass filter	Maya2000 Pro
DET-MAYAPRO-UV	Hamamatsu S10420 detector, installed, w/UV window	Maya2000 Pro
DET-MAYAPRO-VIS	Hamamatsu S10420 detector, installed, w/VIS window	Maya2000 Pro
DET-MAYAPRO-WINDOWLESS	Hamamatsu S10420 detector, installed, with no window options; required for VUV applications	Maya2000 Pro
MAYA-DEEP-UV	DET-MAYAPRO-UV, installed, w/MgF_2 window in place of standard UV window	Maya2000 Pro

Technical Tip

Just as flexibility is built into your spectrometer options, so, too, is flexibility built in to your experiment parameters. We use the term Scope Mode in software to indicate "raw signal" coming from the spectrometer. The Scope Mode spectrum is the digital signal created from the detector's analog signal, which is generated as the result of photons being converted into electrons. The arbitrary units of the Scope mode spectrum are called "counts."

By changing the integration time, adjusting signal averaging and so on you can condition the raw signal to maximize intensity or reduce noise, for example. Once you have optimized your base signal you are ready to enter a Processed Mode. Processed data involves taking a dark, taking a reference and then going into a specific mode such as absorbance, transmission, reflection, relative irradiance, absolute irradiance, color and so on. In a Processed Mode the y-axis units are no longer arbitrary and therefore can be used to make qualitative, and in some cases quantitative, comparisons.

QE65000 and Maya2000 Pro Spectrometers

Choosing the Right Grating

Groove Density

The groove density (lines/mm^{-1}) of a grating determines its dispersion, while the angle of the groove determines the most efficient region of the spectrum. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range.

Spectral Range

The dispersion of the grating across the linear array is also expressed as the "size" of the spectra on the array. The spectral range (bandwidth) is a function of the groove density and does not change. When you choose a starting wavelength for a spectrometer, you add its spectral range to the starting wavelength to determine the wavelength range. For several gratings, the spectral range of a grating varies according to the starting wavelength range. The rule of thumb is this: The higher the starting wavelength, the more truncated the spectral range.

Blaze Wavelength

For ruled gratings, the blaze wavelength is the peak wavelength in an efficiency curve. For holographic gratings, it is the most efficient wavelength region.

Best Efficiency (>30%)

All ruled or holographically etched gratings optimize first-order spectra at certain wavelength regions; the "best" or "most efficient" region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted. For example, Grating 1 has about a 650 nm spectral range, but is most efficient from 200-575 nm. In this case, wavelengths >575 nm will have lower intensity due to the grating's reduced efficiency.

Grating and Wavelength Range

With a choice of multiple grating options, you can easily customize your QE65000 and Maya2000 Pro Spectrometers for various applications across the UV-Shortwave NIR. Our gratings are fixed in place at the time of manufacture. Also, we've added grating options that provide flexibility for UV applications, Raman and more. A table describing these new gratings, as well as efficiency curves and other information, is available beginning on page 46 and on our website.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
HC-1 w/QE65000	UV-NIR	300/600 (variable)	750 nm	Variable	200-950 nm
HC-1 w/Maya2000 Pro	UV-NIR	300/600 (variable)	850 nm	Variable	200-1050 nm
H1	UV	600	373-390 nm	300 nm	200-575 nm
H2	UV-VIS	600	365-390 nm	400 nm	250-800 nm
H3	VIS-Color	600	360-386 nm	500 nm	350-850 nm
H4	NIR	600	360-377 nm	750 nm	530-1100 nm
H5	UV-VIS	1200	180-193 nm	Holographic UV	200-400 nm
H6	NIR	1200	123-170 nm	750 nm	500-1100 nm
H7	UV-VIS	2400	63-90 nm	Holographic UV	200-500 nm
H9	VIS-NIR	1200	145-180 nm	Holographic VIS	400-800 nm
H10	UV-VIS	1800	83-123 nm	Holographic UV	200-635 nm
H11	UV-VIS	1800	66-120 nm	Holographic VIS	320-720 nm
H12	UV-VIS	2400	52-88 nm	Holographic VIS	260-780 nm*
H13	UV-NIR	300	790 nm	500 nm	300-1100 nm
H14	NIR	600	360-370 nm	1000 nm	650-1100 nm

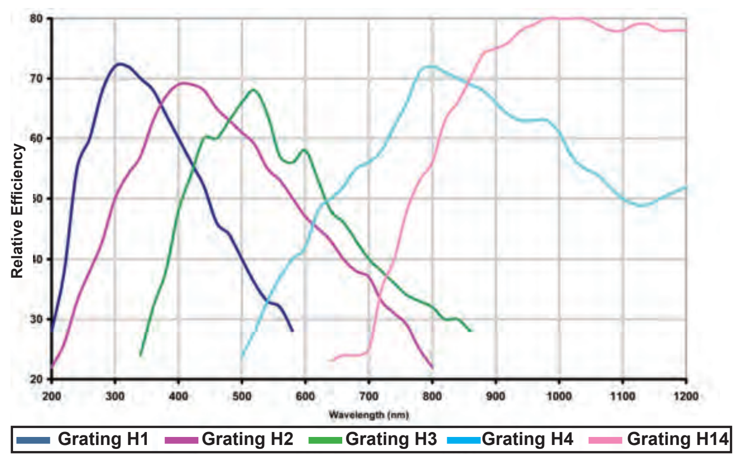
*Consult an Applications Scientist regarding setups >720 nm.

QE65000 and Maya2000 Pro Spectrometers

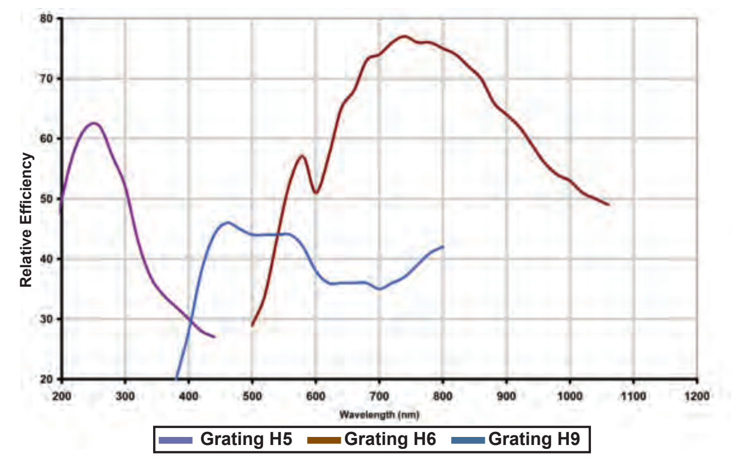
Gratings for QE65000/Maya2000 Pro Spectrometers

The graphs below are grating efficiency curves for gratings with groove densities of 600, 1200, 1800 and 2400 mm^{-1}. Additional information is available at www.oceanoptics.com/Products/bench_grating_hr.asp. Newer grating curves are on the next page.

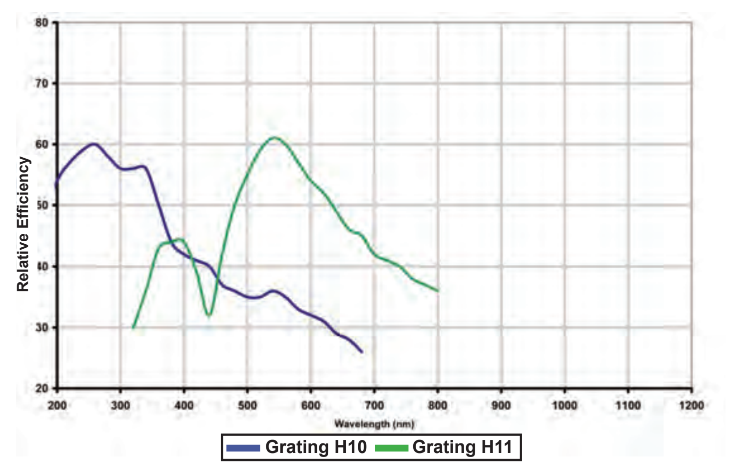
Groove Density of 600 mm^{-1}



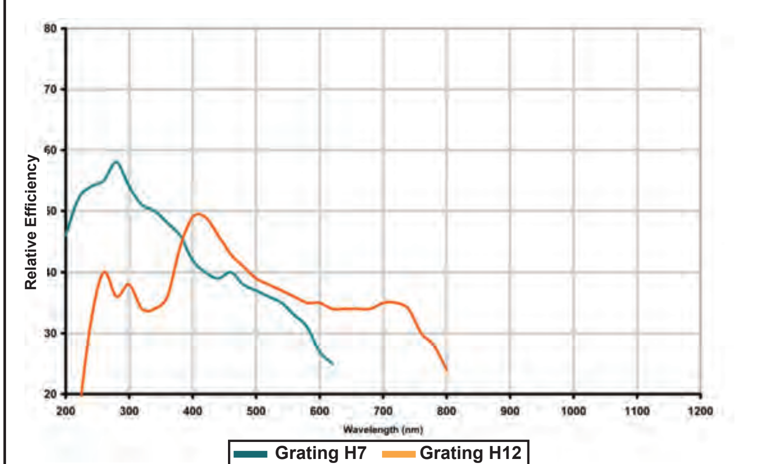
Groove Density of 1200 mm^{-1}



Groove Density of 1800 mm^{-1}



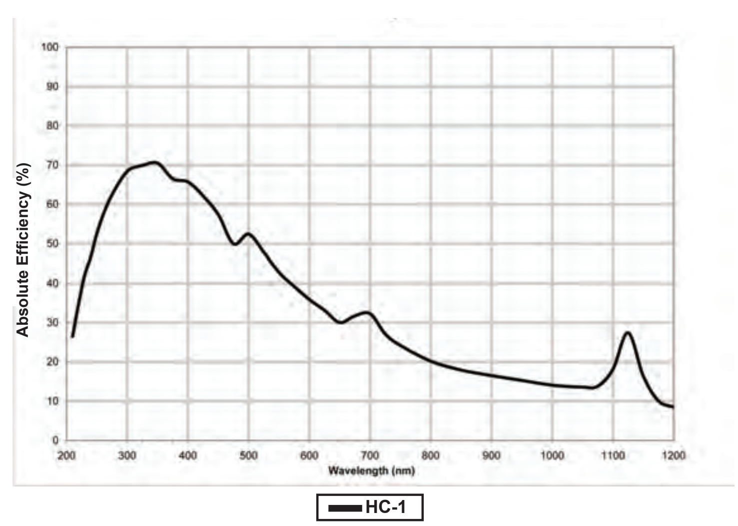
Groove Density of 2400 mm^{-1}



Grating Selection Tips:

- These efficiency curves relate only to the grating. System response is affected by a number of variables, including detector response.
- Grating selection often involves trade-offs. For example, gratings with very high groove density (mm^{-1}) allow greater optical resolution but at the expense of a truncated spectral range. If the user is characterizing two or three closely aligned laser wavelengths, such a trade-off of resolution for range might be acceptable. For other applications, a wider range with good resolution would make better sense.
- We've added several different gratings to provide even more flexibility. Turn the page for details.

Variable Groove Density of 600 mm^{-1}/300 mm^{-1}



QE65000 and Maya2000 Pro Spectrometers

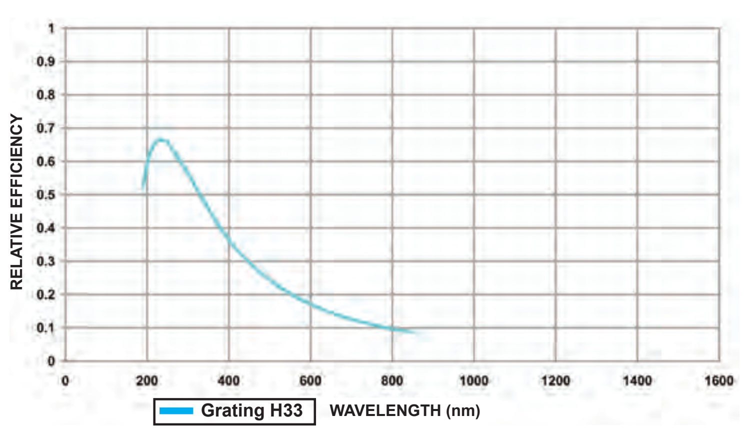
Gratings for QE65000/Maya2000 Pro Spectrometers

We've added grating options for QE65000 and Maya2000 Pro Spectrometers that provide added flexibility for UV applications, Raman analysis and more. A table describing these new gratings, as well as efficiency curves and other information, is available beginning on this page and is posted at our website. Please take note that the x and y axis scaling varies from graph to graph. These new gratings are also available for use in HR Series Spectrometers.

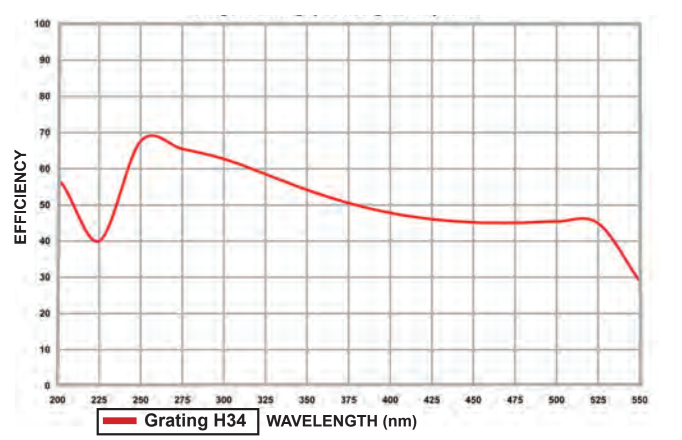
New grating options are just one area of enhanced performance we've addressed with our high-sensitivity, scientific-grade spectrometer offering. Soon to be released are spectrometer options with even greater sensitivity, improved response in certain regions from the UV-NIR, replaceable slits and improved thermal wavelength stability. With our extensive offering of gratings and optical bench accessories, thousands of customized spectrometer configurations are possible. That's flexibility that few manufacturers can match.

Grating Number	Intended Use	Groove Density	Blaze Wavelength	Best Efficiency (>30%)
H33	Absorbance	300	200 nm	200-450 nm
H34	UV Raman	3600	250 nm	200-550 nm
H35	NIR Raman	1200	1000 nm	525-1625 nm
H36	VIS Raman	900	500 nm	325-1225 nm
H5U	Absorbance	1200	250 nm	225-450 nm
H7U	Absorbance	2400	240 nm	200-800 nm
H10U	Absorbance	1800	250 nm	210-475 nm

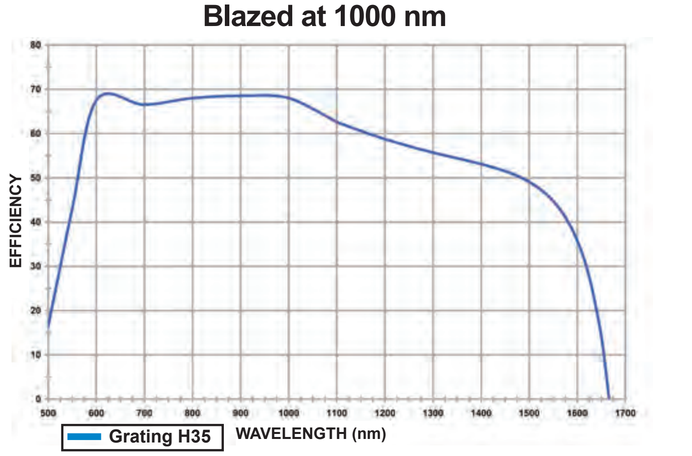
Groove Density of 300 mm^{-1}



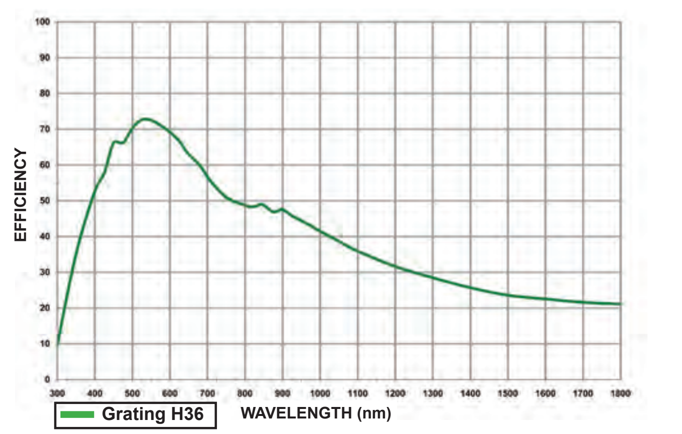
Groove Density of 3600 mm^{-1}



Groove Density of 1200 mm^{-1}, Blazed at 1000 nm



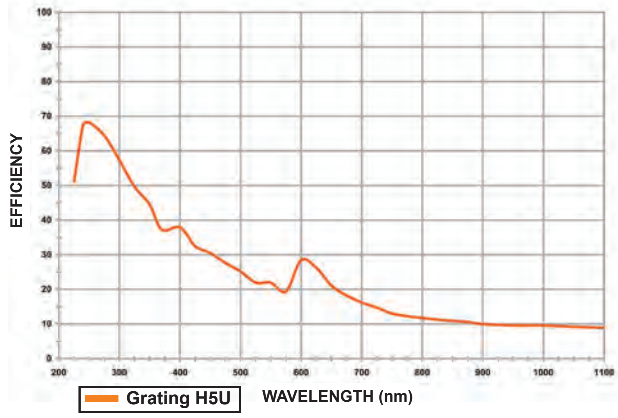
Groove Density of 900 mm^{-1}



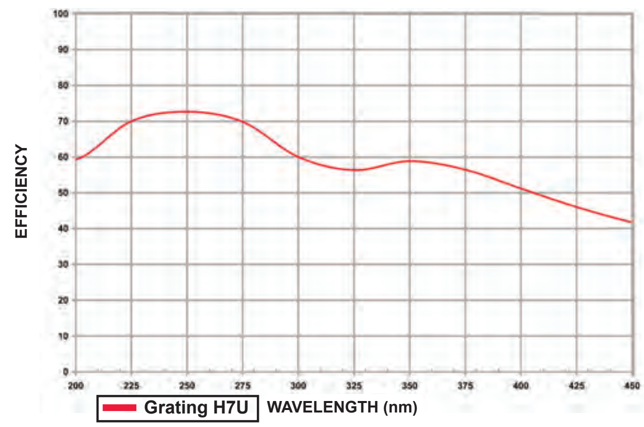
QE65000 and Maya2000 Pro Spectrometers

Gratings for QE65000/Maya2000 Pro Spectrometers

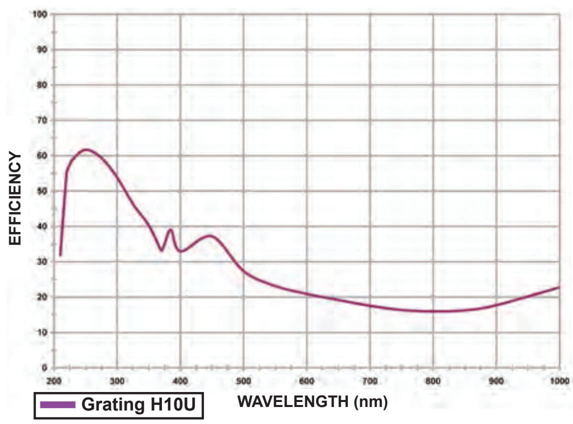
Groove Density of 1200 mm^{-1}, Blazed at 1000 nm



Groove Density of 2400 mm^{-1}



Groove Density of 800 mm^{-1}



Technical Tip: Ruled or Holographic?

A ruled grating is formed by mechanically ruling grooves into a thin coating of gold or aluminum on a large glass blank. Ruled gratings provide good performance at lower groove densities and over broad ranges. Holographic gratings are formed by the interference of expanded Gaussian beams at the surface of a photoresist-covered substrate that is chemically developed into a master grating. The grating may be coated or replicated.

Tradeoffs with ruled and holographic gratings include performance at high or low groove frequencies, the diffraction efficiency or intensity diffracted into the appropriate order, and stray light performance.

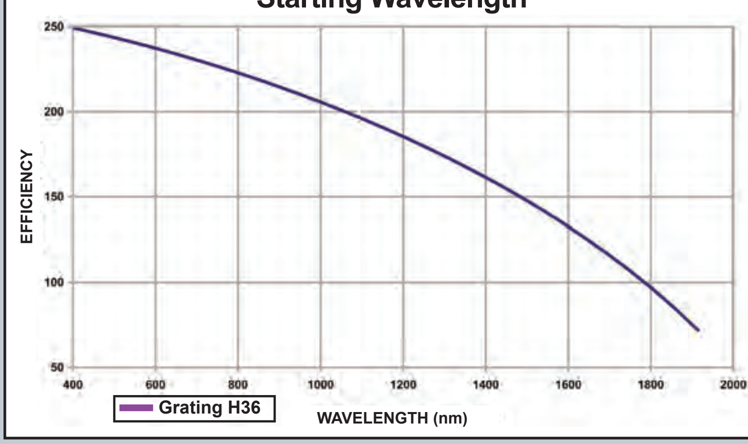
New Grating #H36 Ideal for Modular QE65000 Raman Systems

Grating #H36 is a 900 mm-1 grating that is well suited for applications over a wide UV-NIR range and makes a great choice for modular Raman systems utilizing the QE65000 Spectrometer.

The grating is blazed at 500 nm and has good response at both the 532 nm and 785 nm laser illumination wavelengths typical of Raman spectroscopy. In the graph here, you'll see the predicted spectral range possible for Grating #H36 as a function of starting wavelength.

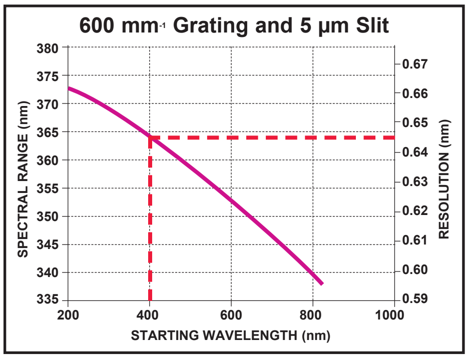
Details on modular and turnkey Raman options are available in the LIBS and Raman section.

Predicted Spectral Range for Grating H36 by Starting Wavelength

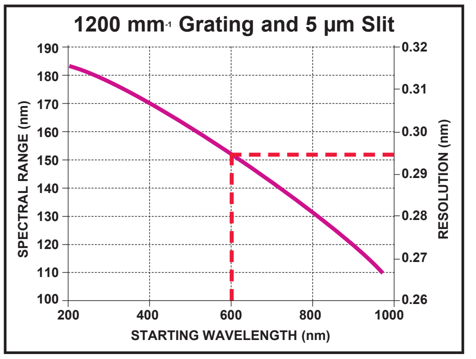


QE65000 Spectrometers

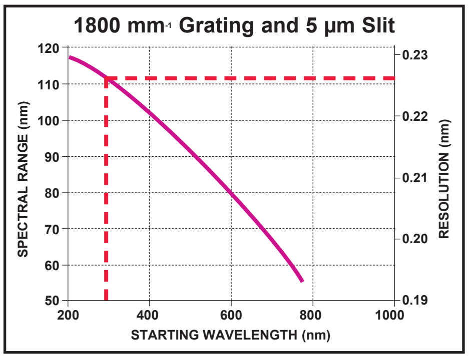
Predicted Ranges and Resolution



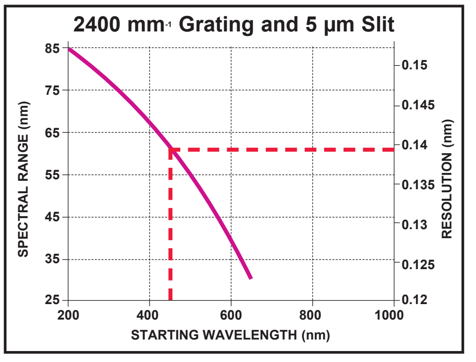
Example:
If the starting wavelength is 400 nm, then the range is ~364 nm, providing a 400-764 nm wavelength range and 0.645 nm resolution.



Example:
If the starting wavelength is 600 nm, then the range is ~152 nm, providing a 600-752 nm wavelength range and 0.295 nm resolution.



Example:
If the starting wavelength is 300 nm, then the range is ~112 nm, providing a 300-412 nm wavelength range and 0.226 nm resolution.



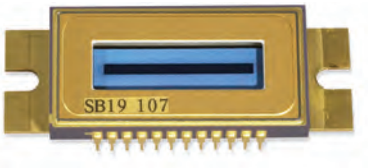
Example:
If the starting wavelength is 450 nm, then the range is ~62 nm, providing a 450-512 nm wavelength range and 0.139 nm resolution.

Note: These predicted range and resolution figures apply only to QE65000 Spectrometers.

QE65000 Detector

About the QE65000 Detector

The QE65000's Hamamatsu S7031-1006 FFT-CCD area detector provides 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). The TE-cooled detector features low noise and low dark signal, which enables low-light-level detection and long integration times, thus achieving a wide dynamic range. Maya2000 Pro Spectrometers have a similar detector but without the TE cooling device.



The S7031 is a 2D array, which allows us to bin pixels in a vertical column to acquire light from the entire height of the spectrometer's slit image. This improves light collection and signal-to-noise significantly. Because the detector is back-thinned (or back-illuminated), it has great native response in the UV and does not require the UV detector upgrade that we apply to other detectors.

In our spectrometers with linear CCDs, the slit's width, not its height, regulates the amount of light entering the bench because linear CCDs cannot efficiently collect the light from the entire height of the slit. But in the QE65000, the 2D area detector can better take advantage of the height of the entrance slit and the additional light, greatly improving system sensitivity.