

Optical Resolution

Optical resolution of a monochromatic source -- -- measured as Full Width Half Maximum (FWHM) -- depends on the **groove density** (mm^{-1}) of the grating and the **diameter** of the entrance optics (optical fiber or slit). In configuring your spectrometer, consider two important trade-offs:

- 1) Resolution increases with an increase in the groove density of the grating, but at the expense of spectral range and signal strength; and
- 2) Resolution increases as the slit width or fiber diameter decreases, but at the expense of signal strength.

How to Calculate the Approximate Optical Resolution in nm (FWHM)

1. Determine the Spectral Range of the Grating.

For USB2000, JAZ, USB4000 Models:

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
1	UV	600	650 nm	300 nm	200-575 nm
2	UV-VIS	600	650 nm	400 nm	250-800 nm
3	VIS-Color	600	650 nm	500 nm	350-850 nm
4	NIR	600	625 nm	750 nm	530-1100 nm
5	UV-VIS	1200	300 nm	Holographic UV	200-400 nm
6	NIR	1200	200-270 nm	750 nm	500-1100 nm
7	UV-VIS	2400	100-140 nm	Holographic UV	200-500 nm
8	UV	3600	50-75 nm	Holographic UV	290-340 nm
9	VIS-NIR	1200	200-270 nm	Holographic VIS	400-800 nm
10	UV-VIS	1800	100-190 nm	Holographic UV	200-635 nm
11	UV-VIS	1800	120-160 nm	Holographic VIS	320-720 nm
12	UV-VIS	2400	50-120 nm	Holographic VIS	260-780 nm
13	UV-VIS-NIR	300	1700 nm	500 nm	300-1100 nm
14	NIR	600	625 nm	1000 nm	650-1100 nm

For HR2000, HR4000, QE65000, and Maya Models:

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
HC-1	UV-NIR	300	200-1100 nm	variable	200-1100 nm
H1	UV	600	425-445 nm	300 nm	200-575 nm
H2	UV-VIS	600	415-445 nm	400 nm	250-800 nm
H3	VIS-Color	600	410-440 nm	500 nm	350-850 nm
H4	NIR	600	410-430 nm	750 nm	530-1100 nm
H5	UV-VIS	1200	205-220 nm	Holographic UV	200-400 nm
H6	NIR	1200	140-195 nm	750 nm	500-1100 nm
H7	UV-VIS	2400	72-102 nm	Holographic UV	200-500 nm
H9	VIS-NIR	1200	165-205 nm	Holographic VIS	400-800 nm
H10	UV-VIS	1800	95-140 nm	Holographic UV	200-635 nm
H11	UV-VIS	1800	75-135 nm	Holographic VIS	320-720 nm
H12	UV-VIS	2400	60-100 nm	Holographic VIS	260-780 nm
H13	UV-NIR	300	800-900 nm	500 nm	300-1100 nm
H14	NIR	600	410-420 nm	1000 nm	650-1100 nm

For NIRQuest Models:

NIRQuest Gratings for Preconfigured Setups

Spectrometer	Standard Grating	Groove Density (lines/mm)	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
NIRQuest512	NIR3	150	~800 nm	1100 nm	900-1700 nm
NIRQuest512-2.2	NIR2	100	~800 nm	1100 nm	900-2050 nm
NIRQuest256-2.1	NIR2	100	1150 nm	1600 nm	900-2050 nm
NIRQuest256-2.5	NIR1	75	1425 nm	1700 nm	1075-2500 nm

NIRQuest Gratings - All Options

Grating	Intended Use	Groove Density (lines/mm)	Spectral Range*	Blaze Wavelength	Best Efficiency(>30%)
NIR1	NIRQuest256-2.5	75	1600 nm	1700 nm	1075-2500 nm
NIR2	NIRQuest512-2.2 NIRQuest256-2.1, NIRQuest256-2.5	100	1200 nm	1600 nm	900-2050 nm
NIR3	NIRQuest512, NIRQuest512-2.2 NIRQuest256-2.1, NIRQuest256-2.5	150	~800 nm	1100 nm	900-1700 nm
NIR10	NIRQuest512, NIRQuest512-2.2 NIRQuest256-2.1, NIRQuest256-2.5	300	350-380 nm	1200 nm	750-2200 nm
NIR11	NIRQuest512, NIRQuest512-2.2 NIRQuest256-2.1, NIRQuest256-2.5	400	240-290 nm	1600 nm	980-2500 nm
NIR12	NIRQuest512, NIRQuest512-2.2 NIRQuest256-2.1, NIRQuest256-2.5	500	160-220 nm	1370 nm	900-2500 nm
NIR13	NIRQuest512, NIRQuest512-2.2 NIRQuest256-2.1, NIRQuest256-2.5	600	100-180 nm	1200 nm	800-2500 nm
NIR14	NIRQuest512	1000	50-90 nm	1310 nm	900-1700 nm

Additional grating options, adjustments to starting and ending wavelengths and similar customization may be available. Please contact an Applications Scientist for details.

2. Divide the Spectral Range of the Grating by the Number of Detector Elements. The resulting value is the Dispersion.

$$\text{Dispersion (nm/pixel)} = \text{Spectral Range of the Grating} / \text{Number of Detector Elements}$$

The table below lists the Detector Elements for various spectrometer benches and models.

Spectrometer	Number of Detector Elements
--------------	-----------------------------

Jaz Spectrometer	2048
USB2000 Spectrometer	2048
USB2000+ Spectrometer	2048
USB4000 Spectrometer	3648
HR2000 Spectrometer	2048
HR4000 Spectrometer	3648
NIR256-2.1 Spectrometer	256
NIR256-2.5 Spectrometer	256
NIR512 Spectrometer	512
NIR512-2.2 Spectrometer	512
QE65000 Spectrometer	1044

3. Determine the Pixel Resolution

The pixel resolution is listed below for various sizes of slits (or the optical fiber diameter if the fiber is the limiting factor). The width of the entrance aperture slits differs; the Height of all slits are the same (1000 microns).

Spectrometer	5 micron Slit	10 micron Slit	25 micron Slit	50 micron Slit	100 micron Slit	200 micron Slit
Jaz Spectrometer	~3.0 pixels	~3.2 pixels	~4.2 pixels	~6.5 pixels	~12.0 pixels	~24.0 pixels
USB2000 Spectrometer	~3.0 pixels	~3.2 pixels	~4.2 pixels	~6.5 pixels	~12.0 pixels	~24.0 pixels
USB2000+ Spectrometer	~3.0 pixels	~3.2 pixels	~4.2 pixels	~6.5 pixels	~12.0 pixels	~24.0 pixels
USB4000 Spectrometer	~5.3 pixels	~5.7 pixels	~7.5 pixels	~11.6 pixels	~21.0 pixels	~42.0 pixels
HR2000 Spectrometer	~1.5 pixels	~2.0 pixels	~2.5 pixels	~4.2 pixels	~8.0 pixels	~15.3 pixels
HR2000+ Spectrometer	~1.5 pixels	~2.0 pixels	~2.5 pixels	~4.2 pixels	~8.0 pixels	~15.3 pixels
HR4000 Spectrometer	~2.0 pixels	~3.7 pixels	~4.4 pixels	~7.4 pixels	~14.0 pixels	~26.8 pixels
NIRQuest 512 Optical Resolution	N/A	~1.3 pixels	~2.0 pixels	~2.3 pixels	~4.2 pixels	~7.9 pixels
NIRQuest 512-2.2 Optical Resolution	N/A	~1.3 pixels	~2.0 pixels	~2.3 pixels	~4.2 pixels	~7.9 pixels
NIRQuest 256-2.1 Optical Resolution	N/A	~1.5 pixels	~1.7 pixels	~2.0 pixels	~2.5 pixels	~4.0 pixels
NIRQuest 256-2.5 Optical Resolution	N/A	~1.5 pixels	~1.7 pixels	~2.0 pixels	~2.5 pixels	~4.0 pixels
QE65000 Spectrometer	~2.0 pixels	~2.2 pixels	~2.6 pixels	~3.3 pixels	~4.7 pixels	~8.9 pixels

4. Calculate the Optical Resolution (in nm)

Dispersion (Step 2) x Pixel Resolution (Step 3)

Example: Determine the Optical Resolution of a USB4000 Spectrometer with Grating #3, 10-micron Slit

650 nm (spectral range of Grating #3)/3648 (detector elements in USB4000) = 0.18 nm/pixel x 5.7 pixels = 1.0 nm

(FWHM)

Note: Values rounded up to nearest tenth.