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How to select optimal Optical Resolution?

Installed Slit in SMA Adapter

The optical resolution is defined as the minimum difference in wavelength that can be separated by the spectrometer. For separation of two spectral lines it is necessary to project them at least two array-pixels apart.

Because the grating determines how far different wavelengths are separated (dispersed) at the detector array, it is an important variable for the resolution. The other important parameter is the width of the light beam entering the spectrometer. This is basically the installed fixed entrance slit in the spectrometer, or the fiber core when no slit is installed.

For AvaSpec spectrometers the available slit widths are 5, 10, 25, 50, 100, or 200 µm wide x 1000 µm high, or 500 µm wide x 2000 µm high. The slit image on the detector array for a given wavelength will cover a number of pixels. For two spectral lines to be separated, it is necessary that they are dispersed over at least this image size plus one pixel. When large core fibers are used the resolution can be improved by a slit of smaller size than the fiber core. This effectively reduces the width of the light beam entering the spectrometer optical bench.
The influence of the chosen grating and the effective width of the light beam (fiber core or entrance slit) are shown in the tables provided for each AvaSpec spectrometer instrument.

In Table 3 the typical resolution can be found for the AvaSpec-ULS2048. Please note that for the higher lines/mm gratings the pixel dispersion varies along the wavelength range and improves towards the longer wavelengths.
The resolution in this table is defined as Full Width Half Maximum (FWHM), which is defined as the width in nm of the peak at 50% of the maximum intensity.

Graphs with information about the pixel dispersion can be found in the gratings section as well, so you can optimally determine the right grating and resolution for your specific application.

For larger pixel-height detectors (3648, 2048L, 2048XL) in combination with thick fibers (>200 µm) and a larger grating angle the actual FWHM value can be 10-20% higher than the value in the table. For best resolution small core diameter fibers are recommended.

All data in the resolution tables are based on averages of actual measured data (with 200 µm fibers) of our Quality Control System during the production process.
A typical standard deviation of 10-25%, depending on the slit diameter and the grating should be taken into account. For 10 µm slits the typical standard deviation is somewhat higher, which is inherent to the laws of physics. The peak may fall exactly within one pixel, but may cover 2 pixels causing, a lower measured resolution.

The replaceable slit feature is available on all ULS and NIR spectrometers.
The spectrometers come with one installed slit and a slit kit which includes all 3 other slit sizes, so you can opt for higher resolution (25 µm slit) or higher throughput (200 µm slit) or somewhere in between (50 or 100 µm slits).

Table 3 Resolution (FWHM in nm) for the AvaSpec-ULS2048-USB2

	Slit size (µm)					
Grating (lines/mm)	10	25	50	100	200	500
300	0.80 – 0.90*	1.10-1.20*	2.30	4.60	9.00	20.0
600	0.40 – 0.50*	0.63	1.15	2.31	4.50	10.0
830	0.28	0.40	0.80	1.60	3.20	8.0
1200	0.18 – 0.22*	0.29	0.61	1.18	2.20	5.4
1800	0.10 – 0.16*	0.19	0.35-0.42*	0.80	1.60	3.6
2400	0.08 – 0.11*	0.10 – 0.15*	0.28	0.55	1.10	2.7
3600	0.05 – 0.08*	0.10	0.18	0.38	0.75	1.8

** depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the higher the resolution*

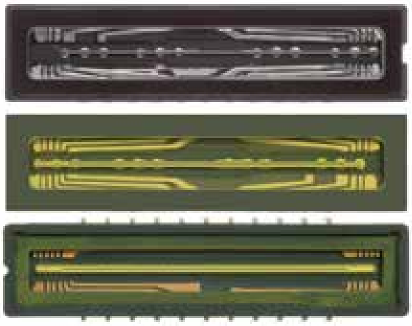
Detector arrays

The AvaSpec line of spectrometers can be equipped with several types of detector arrays. Presently we offer silicon-based CCDs, back-thinned CCDs, and Photo-Diode Arrays for the 200-1100 nm range. A complete overview of each is given in the next section " Sensitivity " in Table 4. For the NIR range (1000-2500 nm) InGaAs arrays are implemented.

All detectors are tested in incoming goods inspection, before they are used in our instruments. Avantes offers full traceability on following detector specifications:

- Dark noise
- Signal to noise
- Photo Response Non-Uniformity
- Hot pixels

StarLine and CompactLine CCD Detectors (AvaSpec-ULS2048/2048L/3648)



The Charged Coupled Device (CCD) detector stores the charge, dissipated as photons strike the photoactive surface. At the end of a controlled time-interval (integration time), the remaining charge is transferred to a buffer and then this signal is being transferred to the AD converter. CCD detectors are naturally integrating and therefore have enormous dynamic range, only limited by the dark (thermal) current and the speed of the AD converter. The 3648-pixel CCD has an integrated electronic shutter function, so an integration time of 10µs can be achieved.

+ Advantages for the CCD detectors are large numbers of pixels (2048 or 3648), high-sensitivity and high-speed.

- Main disadvantage is the lower S/N ratio relative to other detector types.

UV enhancement

For applications below 350 nm with the AvaSpec-ULS2048/2048L/3648 a special DUV-detector coating is required. The uncoated CCD-response below 350 nm is very poor; the DUV lumogen coating enhances the detector response in the region 150-350 nm. The DUV coating has a very fast decay time, typ. in ns range and is therefore useful for fast-trigger LIBS applications.

SensLine Back-thinned CCD Detectors (AvaSpec-ULS2048XL/-2048x64/-HS1024x58/122)

For applications requiring high quantum efficiency in the UV (200-350 nm) and NIR (900-1160 nm) range, combined with good S/N and a wide dynamic-range, back-thinned CCD detectors are the right choice.

Avantes offers cooled and uncooled versions. In case of a 2D-detection the vertical pixels are binned, giving effectivly one high pixel to increase sensitivity.

+ Advantage of the back-thinned CCD detector is the good UV and NIR sensitivity, combined with good S/N and dynamic range.

- Disadvantage is the relatively higher cost.