

RAMAN SPECTROMETERS

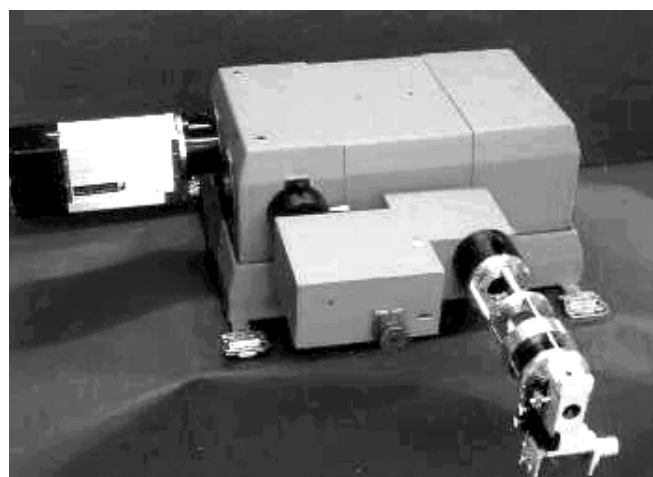
Raman spectroscopy can be generalized as the scattering of light from solid, liquid, or gas sample shifted from the wavelength of the usually monochromatic incident source. It is a weak effect and when investigations are at smaller shifts, it requires that the incident Raleigh scatter is filtered or rejected to prevent interference.

Recent improvements in CCD detectors and notch (sometimes super-notch) holographic rejection filters enable many Raman applications to use a single stage spectrometer. This is particularly true in the Visible and Near Infrared region where filters are readily available. The notch filters provide good rejection of Raleigh scatter and enable operation to 150 or 200 cm^{-1} of the excitation wavelength. The CCD allows simultaneous collection of a reasonable 'window' of spectra. If this sounds like your application, see the Model 207 (667 mm focal length – f/4.7) and Model 2035 instruments in the spectrometer section of our web site located at <http://www.mcphersoninc.com>. The Model 207 is the fastest (most throughput) high resolution instrument available commercially. Combined with the right CCD, filter, and input optics, this can be a ready solution.

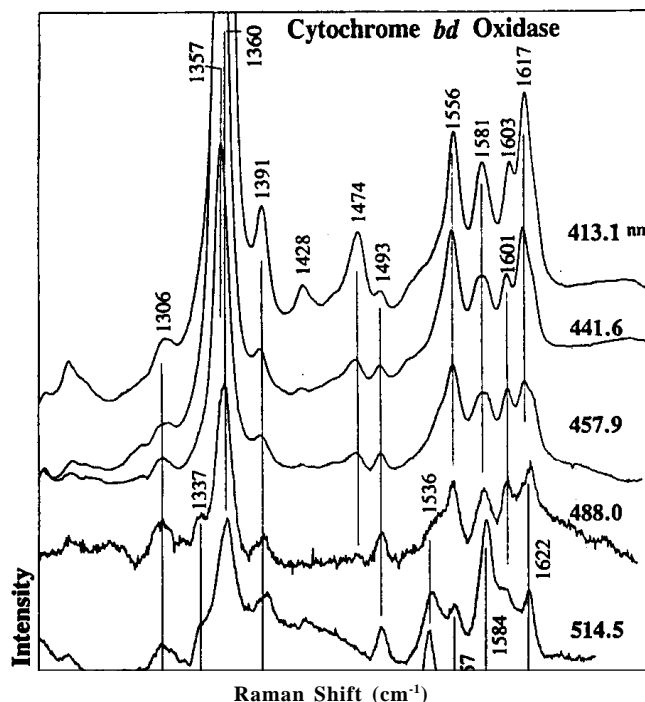
McPherson Raman spectrometers best suit applications calling for:

- Work in the Ultraviolet (in this application perhaps anything less than 488 nm)
- Work at shifts less than 100 or 150 cm^{-1}
- Work at frequently varied excitation wavelengths, e.g., tunable laser excitation particularly in the ultraviolet

We have several standard approaches to this application and as always, there is room for specialization depending on your requirement. We prefer combining a subtractive double spectrometer with a higher resolution system for good spectral resolution. Some approaches are described on the following pages.



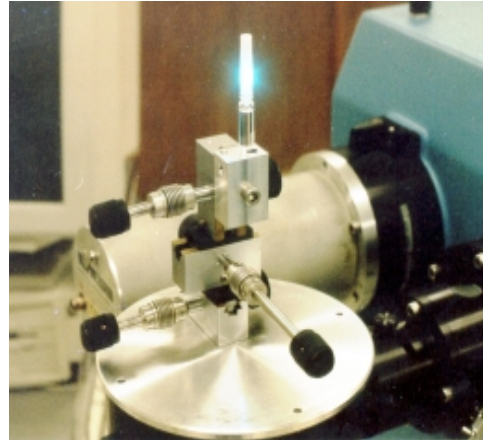
f/4 Triple Monochromator with 667 mm focal length Model 207 and Model 275DS. Unit is shown with macro sample mount and thermoelectrically cooled PMT housing.



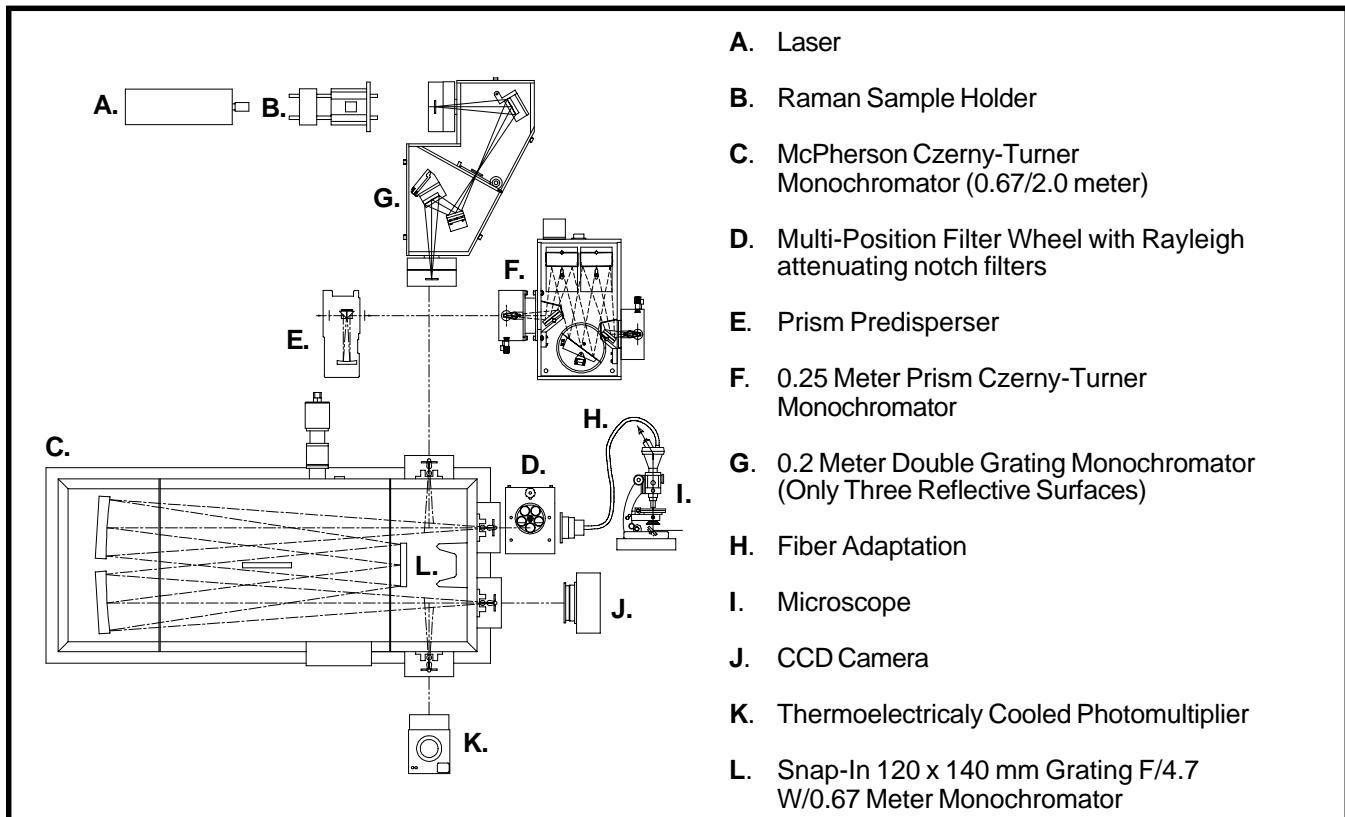
Resonance Raman Spectra of fully reduced cytochrome bd oxidase. Spectra between 413.1-514.5 nm excitation are with McPherson Raman CCD Spectrometer with Princeton Instruments CCD. Laser power between 15-45 mW, 100 micromolar enzyme.¹

ANATOMY OF A RAMAN SYSTEM

Raman systems can be complicated. The dispersive spectrometer is a very important part of the system. There are many other considerations including laser selection, sample environment, detector configuration, delivery and collection optics (macro and/or micro, etc.). If you call on us to deliver a complete system, we will need to discuss the system elements in detail. This task is simplified in cases when users have lasers and sample mounts in their labs. This allows us to focus on the spectrometer that will deliver the exact performance required for an application.



Internal parts of the Model 125 Raman sample chamber



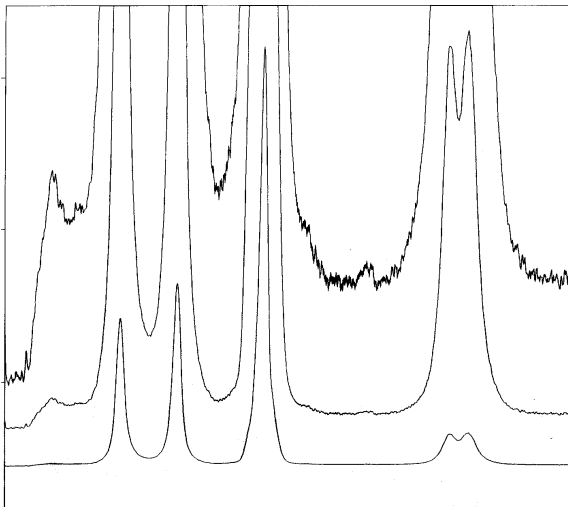
Call 978-256-4512 today to discuss your optics & instruments requirements!

RAMAN SPECTROMETERS

The dispersive Raman spectrometer rejects Raleigh scatter and provides a clear window in which weak Raman scatter can be detected. The spectra should also be spectrally resolved as required for the analysis. How can spectrometers be used to accomplish this?

ADD A PRISM PREDISPERSER

When there is an existing single stage instrument and the investigator wishes to work in the ultraviolet regime - where no filters are available - a simple approach is to add a prism spectrometer. This allows coarse dispersion of the collected signal prior to introduction to the spectrometer. The prism can be tuned to pass the area where Raman signal is and reject, by impinging on the slit, the Raleigh scatter. This is relatively crude and the degree of rejection highly depends on the size of slits used and the imaging quality of the predisperser. Generally, this approach is best used for the ultraviolet (no filters) when Raman is not expected very close to the Raleigh scatter. Wide wavelength regions can be attained by incrementing the prism central wavelength along with that of the main spectrometer. Refer to our Model 608 and or Model 303 prism spectrometers for additional information.



Carbon Tetrachloride (CCl₄) Raman Spectrum collected with 667-mm focal length Model 207, 1-mm diameter capillary, multi-line Argon-Ion laser at 514-nm (10 mW) with liquid Nitrogen cooled CCD camera.

ADD A SPECTROMETER

Making a two-stage grating instrument will improve stray light characteristics and rejection more than the prism approach. This can be useful if the user is content to scan for data acquisition as opposed to using a CCD. A grating based instrument delivers great dispersion, better rejection and stray light, and a much narrower region of spectra passing through the system. Therefore, both instruments must be scanned in good synchronicity to maintain throughput. If set by design at the onset, this should not present a problem. It might be more difficult in the field to retrofit an instrument for this purpose. Given the advantages of adding a subtractive double instead of a single before a spectrometer we prefer the next approach.



Double Spectrometer Model 275 is frequently used in Triple Spectrometer for Raman applications.

ADD A SUBTRACTIVE DOUBLE SPECTROMETER

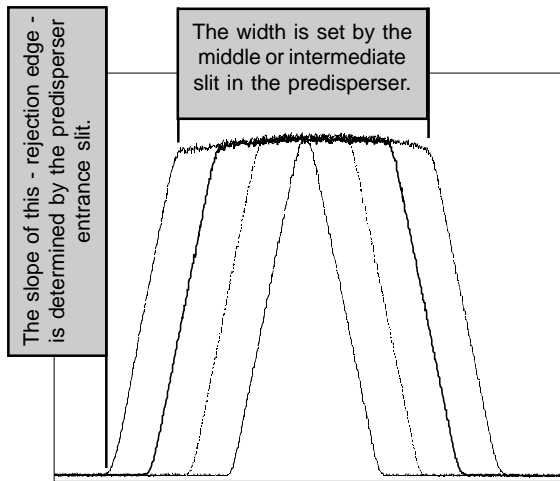
A subtractive double spectrometer adds tremendous flexibility to Raman instrumentation. This addition results in a three-stage or triple spectrometer. These are considered the optimal instruments for Raman work. The design of the subtractive double allows designing in required factors such as the width of the rejection edge. The size of the window of Raman can be viewed simultaneously and assurance of excellent stray light rejection. Furthermore, the primary spectrometer usually used to image spectra onto a CCD can be considered separately, allowing the choice of aperture ratio (f/no.) and resolution characteristics best matching the desired application requirement.

TRIPLE SPECTROMETERS

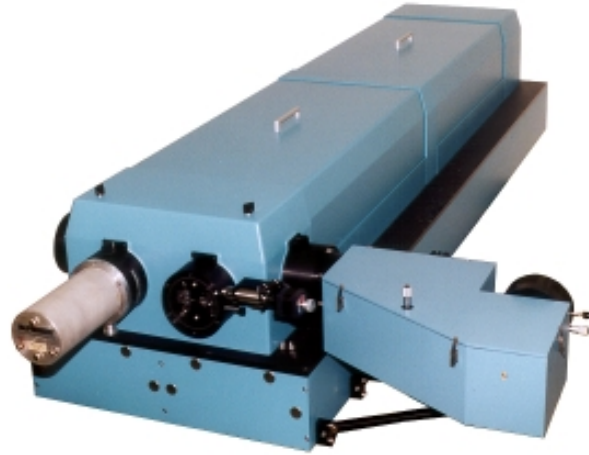
Triple spectrometers are configured by using a relatively short focal length double subtractive spectrometer (McPherson Model 275DS or 2035DS) with a longer focal length spectrometer (McPherson Model 207, 2061B, 209, 2062). The double subtractive spectrometer is responsible for determining the clear 'window' of Raman spectra that can be collected on a CCD. The subtractive predisperser is also responsible for determining the severity of the rejection edge and the overall reduction in scattered light. The long focal length spectrometer is selected to provide the desired dispersion across the CCD or a specific wavelength resolution.

The subtractive or pre-monochromator behaves like a zero disperser. The double is used to select a very specific and adjustable band pass (at the middle or intermediate slit) and then recombine the selected wavelengths into a small, slit size image. The entrance slit size will determine the severity of the rejection edge. Consider your sample size, laser spot size and collection optics when specifying the predispersing monochromator!

For example, the graphs below assume you can present an aperture matched 500 μm image size to the spectrometer entrance slit without losing too much energy. It depicts the clear window and edge formation of the popular Model 275DS.



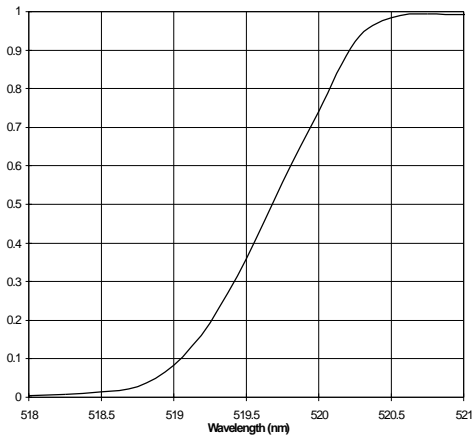
The Model 275DS pre monochromator 'window' of spectra delivered to the long focal length instrument depends on the central slit setting.



The Model 275DS shown above is coupled to the entrance of a 2,000 mm focal length Model 2062 which is an extremely high resolution spectrometer.

Key advantages of the triple spectrometer include continuous wavelength tuning and good operation through the ultraviolet.

Disadvantages that should be noted include much lower throughput and the possibility of longer acquisition times.



Shown above is a Model 275DS pre monochromator rejection edge, collected with 500 μm slits (2 nm band) the rejection edge is a little more than 100 cm^{-1} wide. The clear window through the intermediate slit is about 1600 cm^{-1} wide.