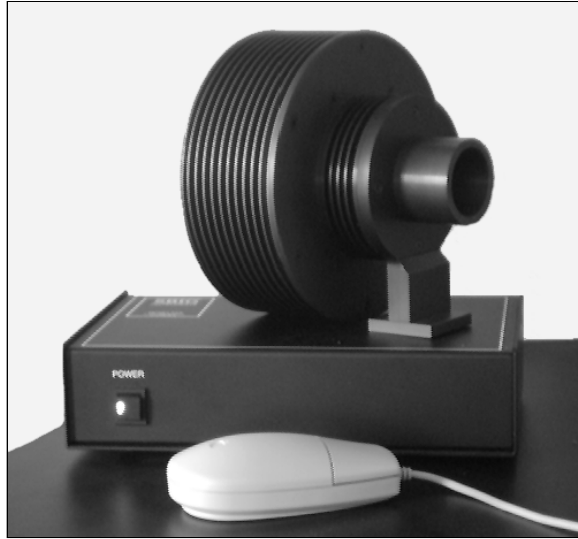


Kestrel™



KestrelSpec™ ST-6
Software Manual
Version 2.4



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Contents

How to Use This Book	4
Learning KestrelSpec	5
Control Palette	7
Displaying a Calibrated X Axis	8
Zooming on Spectra	9
Changing the Spectrum Title	10
Changing the X,Y axes	11
Spectrum Movie	13
Overlay Plots	14
Peak Finder	16
Continuous (XY) Zooming Tools	21
Dragging Tool	22
Spectrum Point Editor	23
Quick Zoom	25
Curve Arithmetic	26
Spectrum Catalog	26
Image Display	31
Making Spectra from an Image	33
Calibrating Spectra with a Cal Curve	34
Laser Beam Profiler Display	36
Constant/Image Math	39
Channel-Profile Plot	42
Using KestrelSpec	43
Setting Up the System	44
Spectrograph Computer Interface	45
Acquiring Data	46
Setting Up for Data Acquisition	47
Setting Up of Binning of CCD Image	48
Setting Up Camera Configuration	50
Formatting Spectrum Curves from Images	52
Calibration	54
Dark Background Subtraction	57
Reference	58
Importing Data	59
Exporting Data	60
Prefs File	61
Printing	61
Paste Curve	62
General Settings	63
Axes Settings	64
Peak, Smooth Threshold Setting	64
Peak Finder Settings	65
Background Subtraction, Flat-Field Correction	66
Transform to Absorbance	66
Plot, Image Styles	67
Curve, Image Processes	68
Create Baseline	69
Renormalize X Axis	70
Integrals (Peak Areas)	71
Common Problems and Solutions	72
Compatibility	72
Spectrograph Control Option	73
Triggered Data Acquisition	77

How to Use This Book

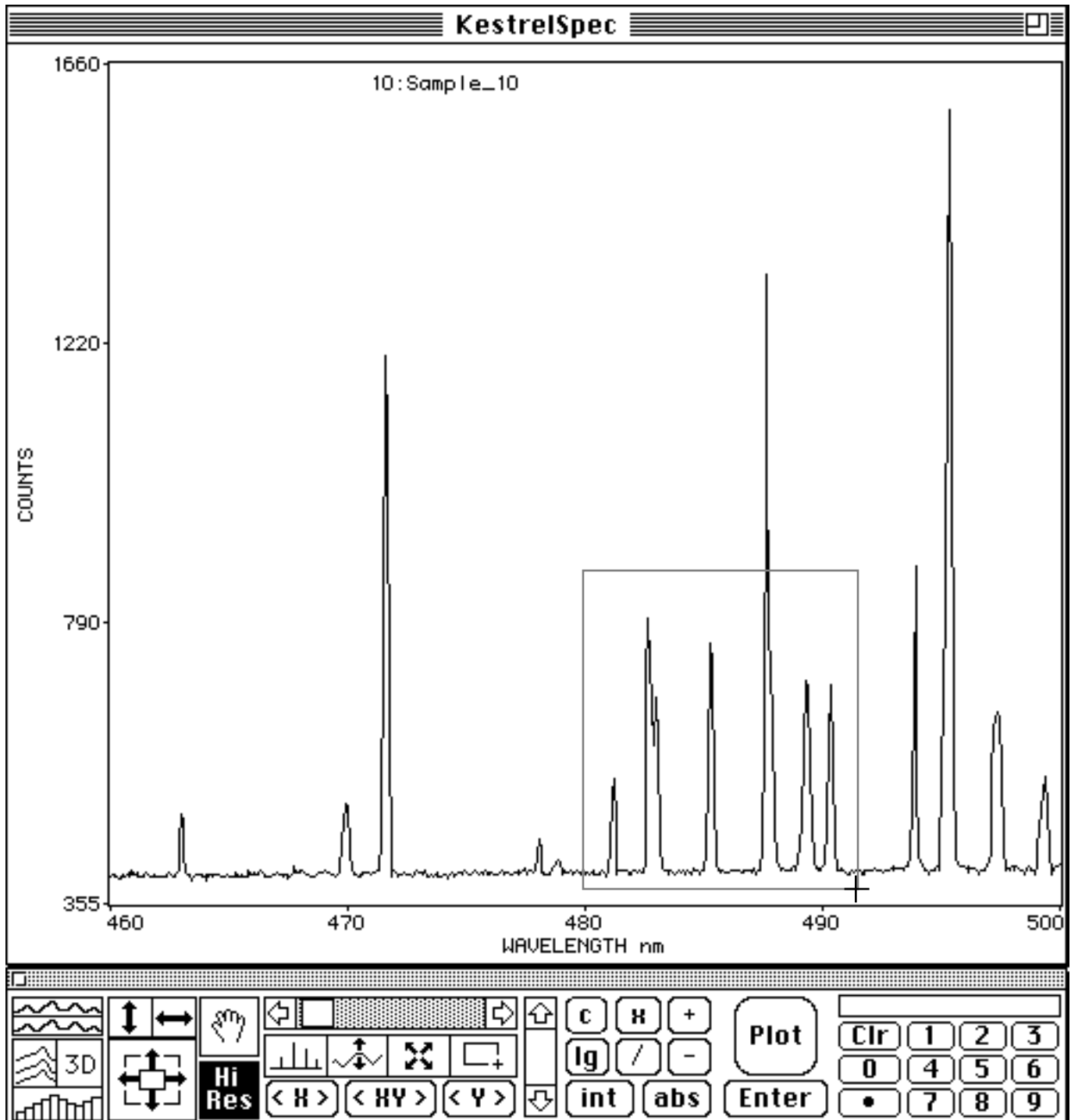
The best way to learn KestrelSpec is to explore its data-acquisition and data-visualization tools on your own. This is a book of hints to guide you in your exploration.

- If you want a brief lesson on getting started with KestrelSpec, see "Learning KestrelSpec."
- When you want to find out more about using the CCD detector and spectrograph to acquire and display data, flip through "Using KestrelSpec."
- For details on various menu commands, spectrograph control, and scripting see "Reference."

Chapter 1:

Learning

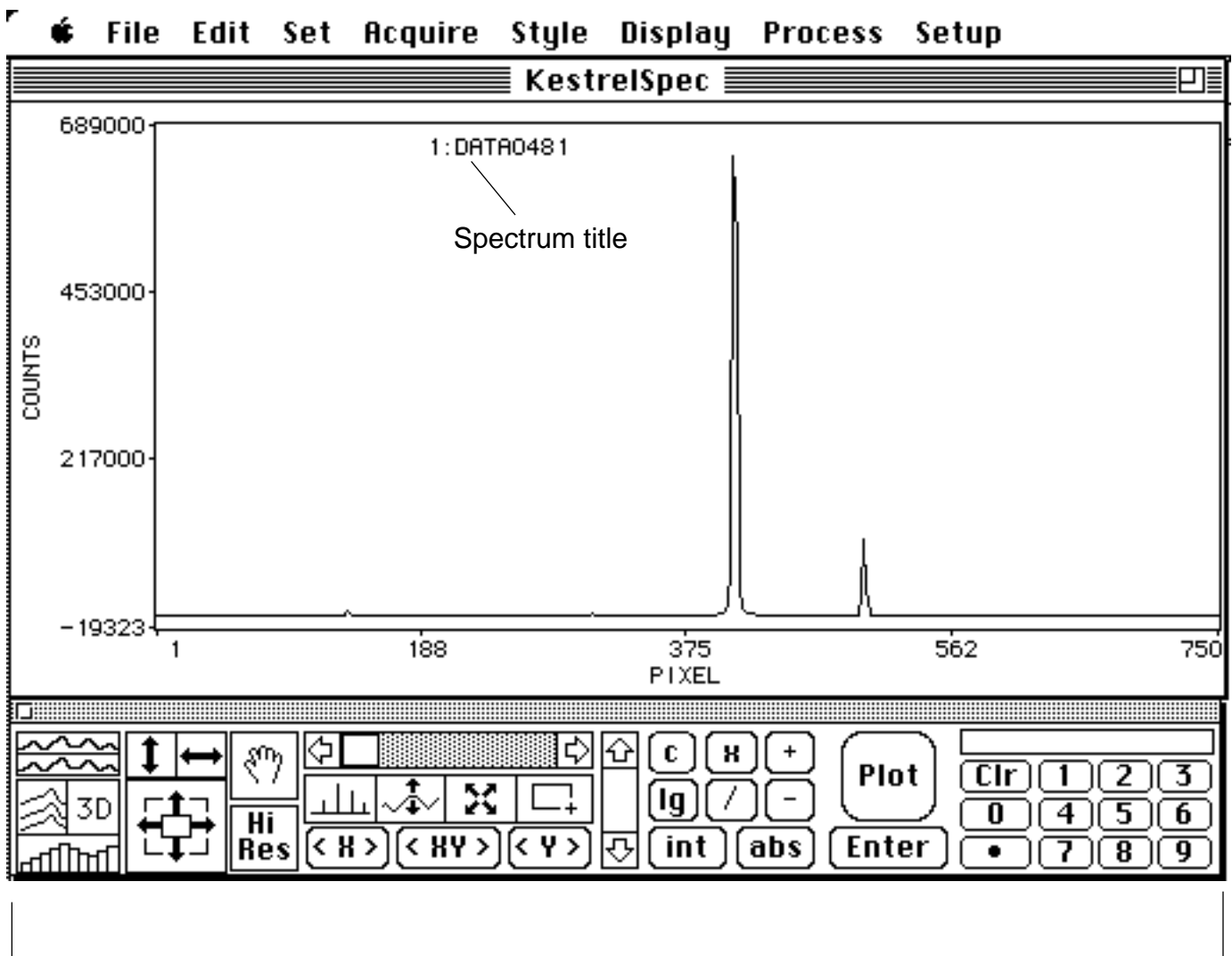
KestrelSpec



Learning KestrelSpec

How to begin:

- Insert the KestrelSpec disk. For faster performance, copy the KestrelSpec program onto your hard disk by dragging its icon to the hard disk window.
- Double click on the document icon titled "Neon-Scan Movie." KestrelSpec will automatically start and load the document.
- **In a few seconds, the screen will look like this:** (the actual window size will depend on your monitor's size).



This is the Control Palette. It has tools for setting up and changing displays of spectra and images, moving the spectrum cursor, selecting areas, and basic math operations.

Control Palette

The control palette is a floating window which gives quick access to a number of tools. Its appearance depends on whether the display shows a spectrum curve plot or an image. Many of the control palette tools are discussed in this chapter on the pages shown in the figures below.

Curve-Plot Mode

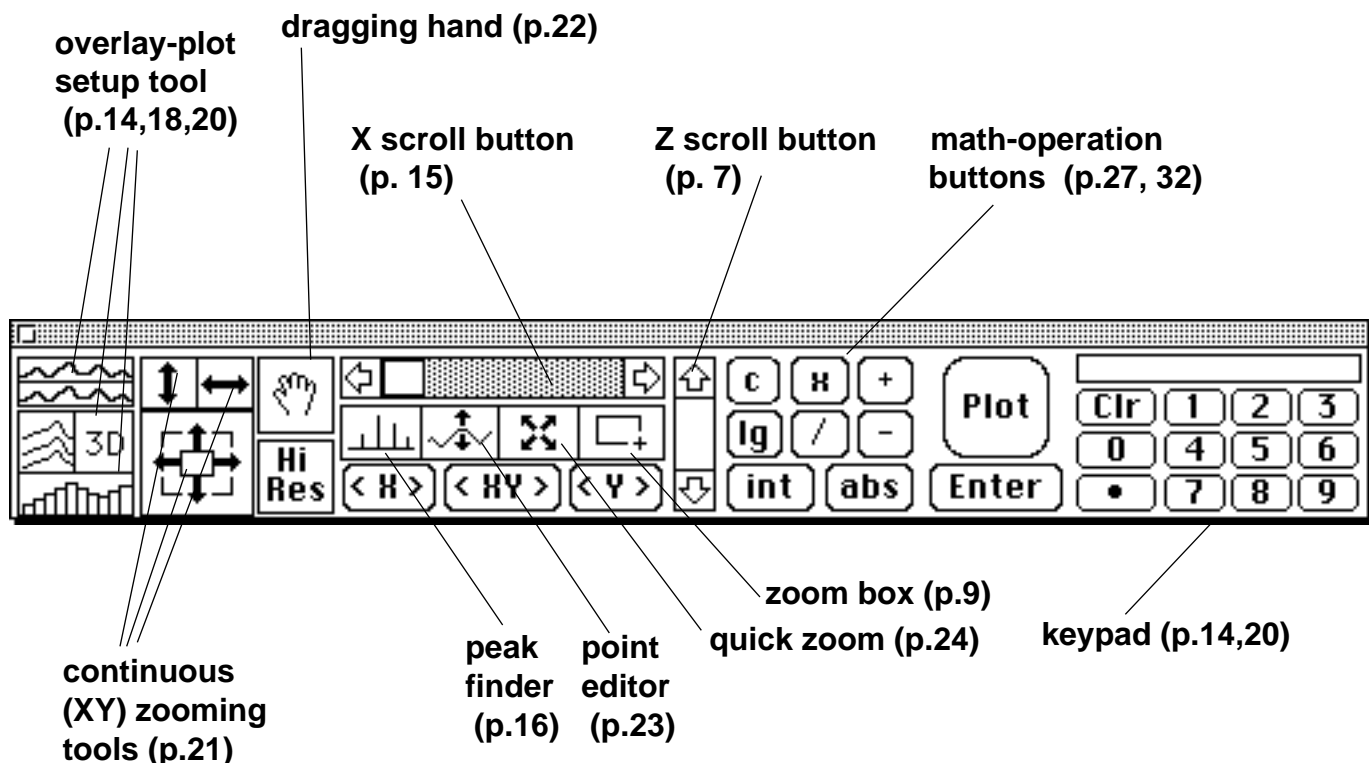
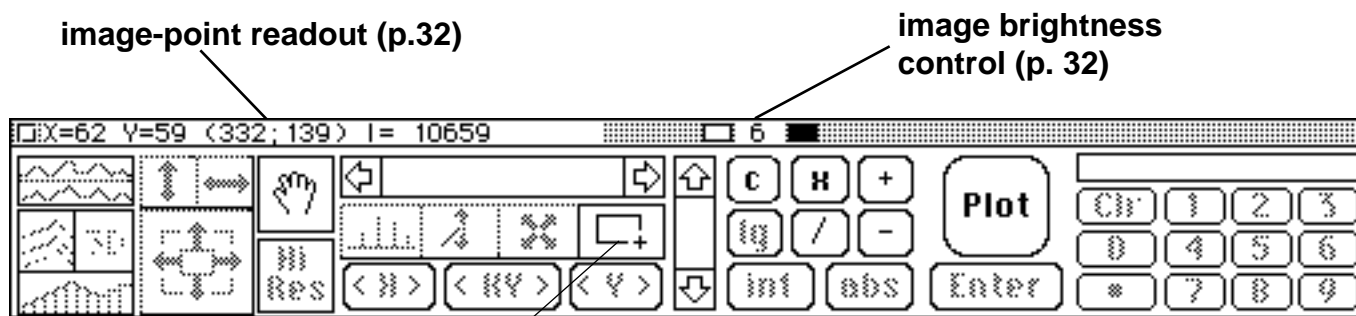


Image-Display Mode



The zoom box can be used to select an area of the image for copying to the clipboard. Hold down the *option* key to have the mean and standard deviation for the selected area displayed in the upper right part of the control palette.

In this book, the following symbols indicate specific actions.



means **click**.
Position the pointer,
then briefly press
and release the
mouse button.



means **drag**.
Position the pointer,
press and hold the
mouse button while
you move the mouse,
then release the
mouse button.

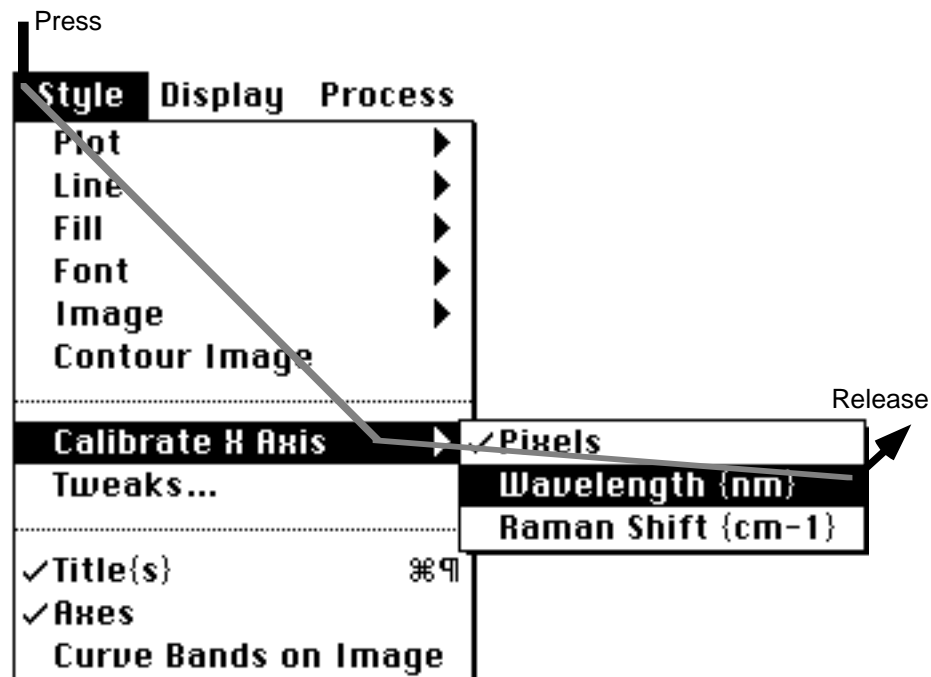
- Click the X,Y autoscale button in the control palette.



This sets the Y axis scale to show the entire range of data, and also causes the X axis to only include the part of the spectrum that has non-zero data.

- To show the X axis in nm (wavelength) units, choose the *Style:Calibrate X Axis:Wavelength* menu.

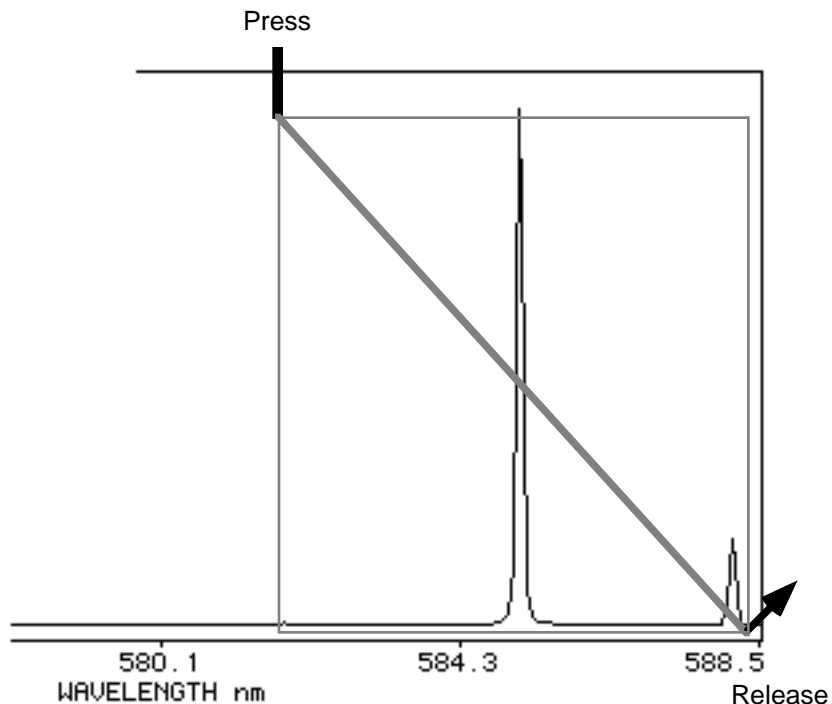
Here's how:



Zoom in on an area of the spectrum:

- Click 

- Then drag in the plot window:

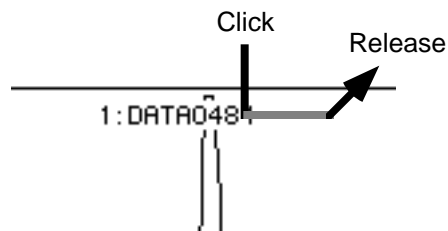


As you drag, a dotted outline encloses the area you select. When you release, the plot is redrawn to show only the area you selected.

- Turn off the zoom-box tool if you don't want to zoom further:

- Click 

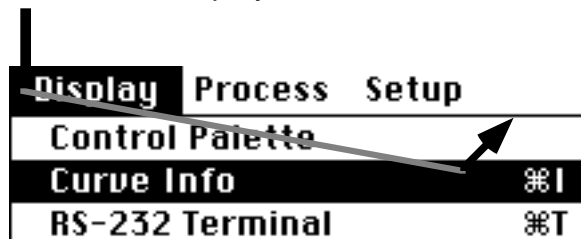
- Drag the spectrum title to a different part of the window (after clicking, wait for the pointer to change to a hand before dragging):



The title will stay in its new location.

Change the title of the spectrum:

- Choose the *Display: Curve Info* menu:



This opens a window with the title, general info and spectrograph info for the curve:

Curve Title	<input type="text" value="DATA0481"/>		
Curve Info	Created 06/22/93 at 15h33m04s; ET= .5s; Exps= 1 Gain= 1; Image Size= 512 x 10; Group Size= 1 x 10; Origin= 23, 204		
Spectrograph Info For This Curve:			
Known Wavelength =	<input type="text" value="580"/>	nm at Pixel	<input type="text" value="251.752"/>
Spectrograph Angle =	<input type="text" value="12.000001"/>	Degrees	
Spec. Focal Length =	<input type="text" value="500"/>	mm	
Grating Grv. Density =	<input type="text" value="1200"/>	g/mm	
Detector Pixel Size =	<input type="text" value="22.195239"/>	microns	
Excitation Wavelen. =	<input type="text" value="514.5"/>	nm	
		<input type="button" value="Cancel"/>	<input type="button" value="OK"/>

- Select the edit file with the curve title:



- The title will highlight itself.

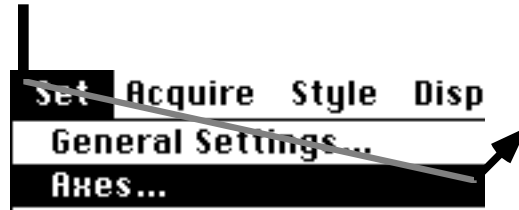


- Type a new title, then click the "OK" button.



Change the X, Y axes:

- Choose the *Set:Axes* menu:



The Axes dialog window opens:

Set the X, Y range of the plot with these edit fields.

These buttons let you adjust the appearance and behavior of the axes.

Axes

X Max pixel

X Min

Y Max

Y Min

Set X Cursor Range

Zero Y Origin **Show All 3D X**

Always Use Curve 0 for Cal

Show Axis Labels **Linearize X**

X:

Y:

Z:

<AUTO> means use the default X axis descriptions (nm, cm-1)

These edit fields set the description that appears on the X, Y and (for channel profile plots) Z axes.

- Turn on "Linearize X" to set X range directly in wavelength units.

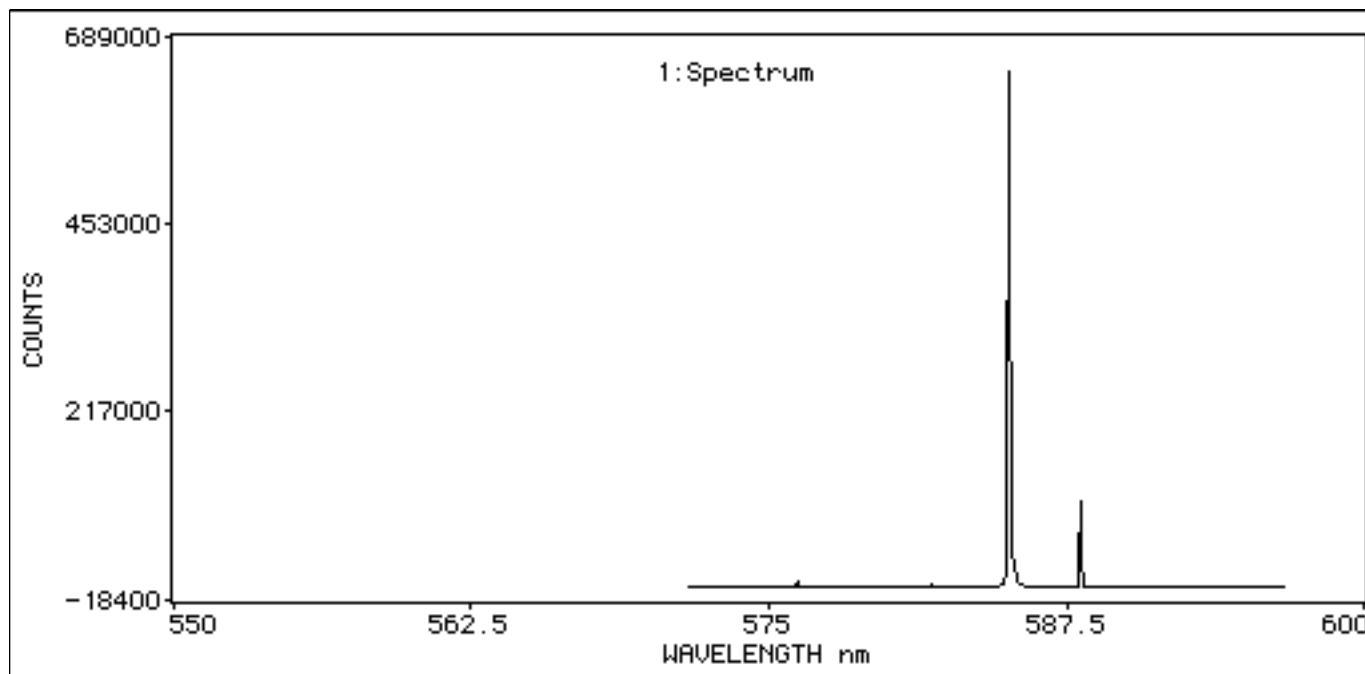


- Type 550 and 600 for the XMin and XMax values.

X Max nm

X Min

- Click "OK."



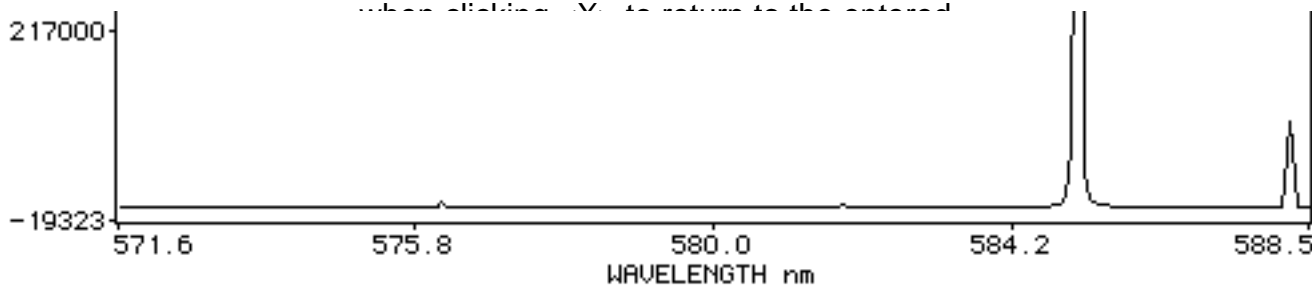
The plot will be redrawn to show the new X axis range. The spectrum curve does not cover the entire range, because it has valid data points ("pixels") for only a fraction of the range.

"Linearize X Axis" makes the divisions on the X axis uniformly spaced in the calibrated units (nm, cm⁻¹, etc.). It also "locks in" the plot X axis to the specified calibrated range.

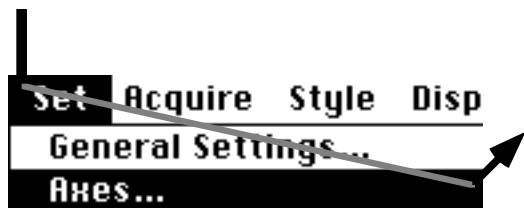
- Select the X autoscale button:

Click 

The plot X-axis range will "snap" to the actual range of valid data points for the displayed spectrum. (Hold down the *option* key when clicking X to return to the entered



- Again, choose the *Set:Axes* menu:

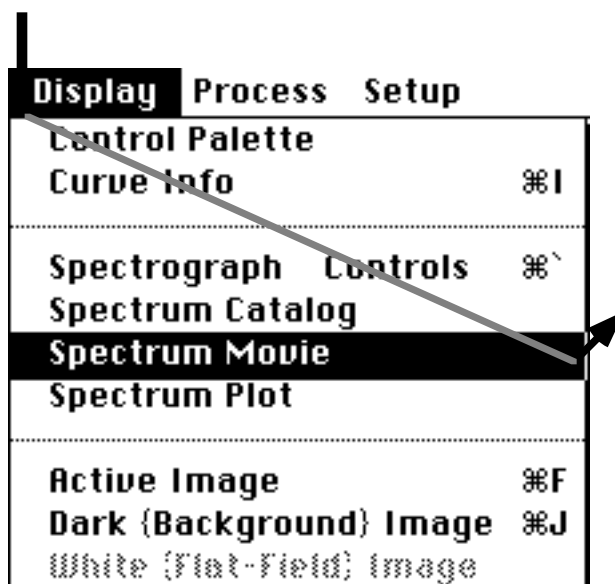


- Turn off "Linearize X."



- Click "OK" to exit the window.

Display the open document as a spectrum movie:



About the Spectrum Movie

The 50 different spectra in the document file will be plotted in rapid sequence. Since each spectrum was obtained (using KestrelSpec's automated spectrograph control option) with a slightly different spectrograph wavelength setting, the peaks in the spectrum appear to move to the left as the movie runs. The X axis wavelength values also change as the movie runs.

To slow the movie to one frame per second, press the *option* key on the keyboard.

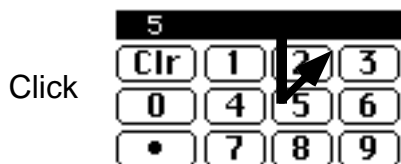
To stop the move, click the STOP button on the control palette (or *return* on the keyboard).



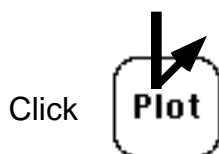
Click **STOP** or *return*.

Plot a different spectrum:

- Click the "5" button on the Control Palette (or on the keyboard).



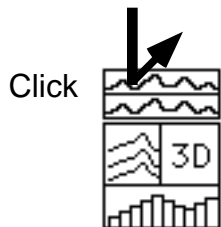
- Click the "Plot" button.



Spectral curve no. 5 is plotted. The wavelength units on the X axis are automatically updated for the new spectrum, since this spectrum's pixels cover a different wavelength range.

Overlay Plots**Create a multi-curve (overlay) stacked plot:**

- Click on the stacked-plot tool on the control palette:



The overlay-plot dialog window will open. Set up the First, Step, and Last values as shown:

Curves in Overlay Plot

First

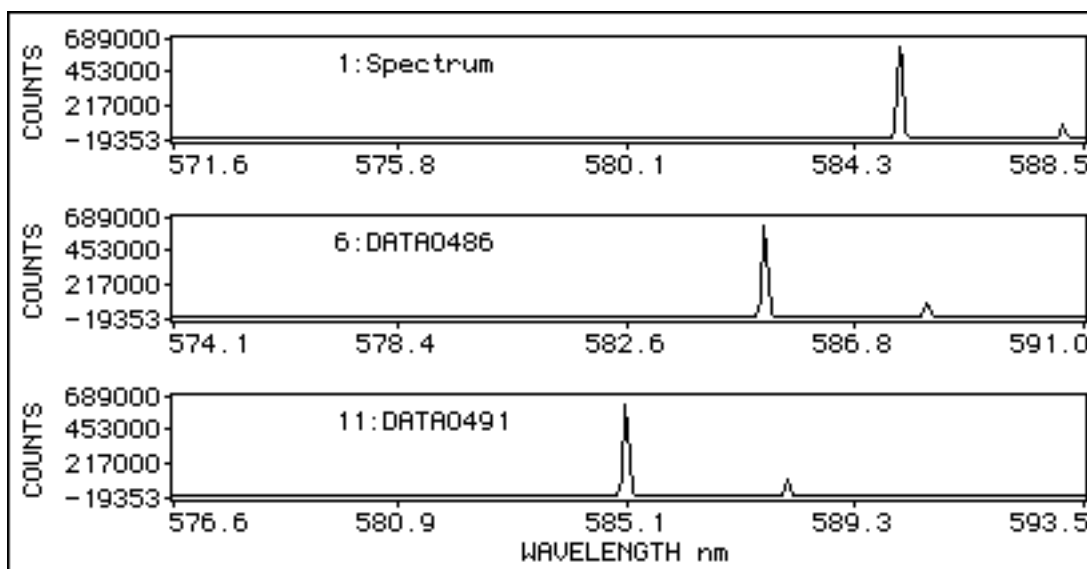
Step

Last

- Click OK.

The stacked plot will be drawn from the top to the bottom of the display window using curves 1,6 and 9:

active
(flashing)
spectrum
curve



The top spectrum will be flashing to indicate that it is the "active curve" (or "active spectrum") in the overlay plot.

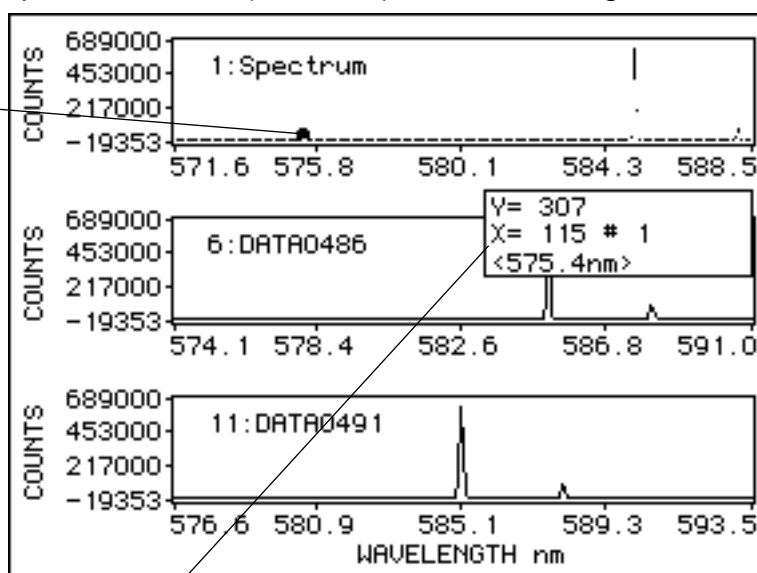
Each of the 3 plots has a different X-axis wavelength range.

- Click in the right arrow of the X scroll button.



The spectrum cursor (small dot) will move along the active curve:

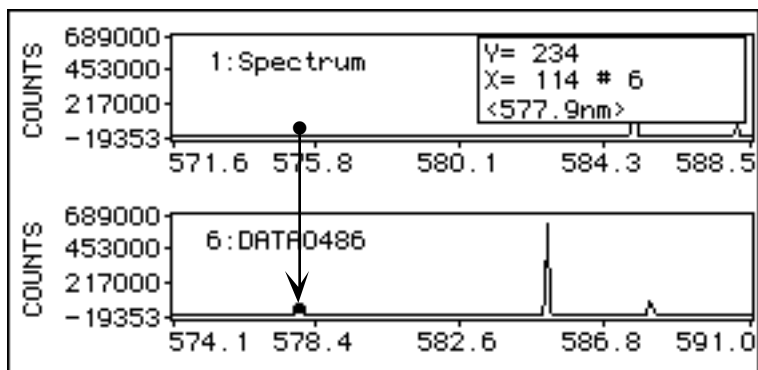
Spectrum cursor
(Move it with the
X scroll button, or
drag it with the
mouse.)



The cursor display box shows the counts (Y), pixel (X) and calibrated X value for the position of the cursor. The calibrated value is enclosed in brackets < > when *Kestrel/Cal* is in use. (The box can be dragged to another position in the window.)

Change the active curve in the overlay plot:

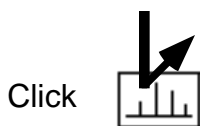
- Click in the lower arrow of the Z scroll button:



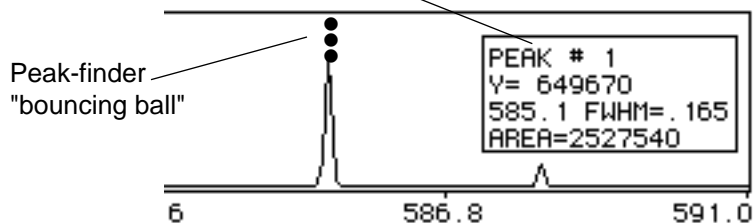
The spectrum cursor will move to the next curve in the display.

Use the peak finder:

- Click in the peak-finder tool:



The peak finder "bouncing ball" will show the highest peak in the spectrum. The peak-info display box details information about the peak.

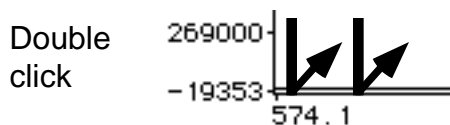


To quit the peak finder, hold down the *shift* key and click in the peak finder tool:



Linearize the overlay plot X axis:

- Open the "Axes" dialog window again using the *Set:Axes* menu, or double-click on the plot axis:



- Click "Linearize X" to turn it on. Set the X range to 580 to 590 nm.

then set X Max, X Min as shown

Axes

X Max nm

X Min

Y Max

Y Min

Set X Cursor Range

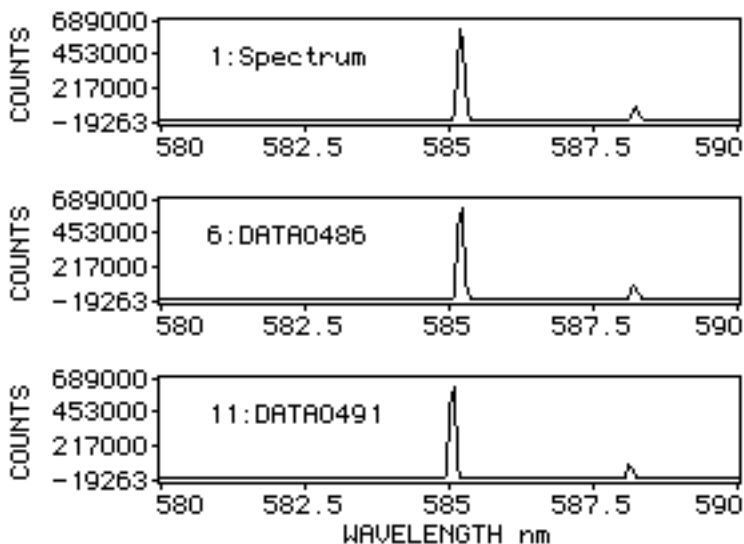
Zero Y Origin Show All 3D X

Always Use Curve 0 for Cal

Show Axis Labels Linearize X

➡ First click here

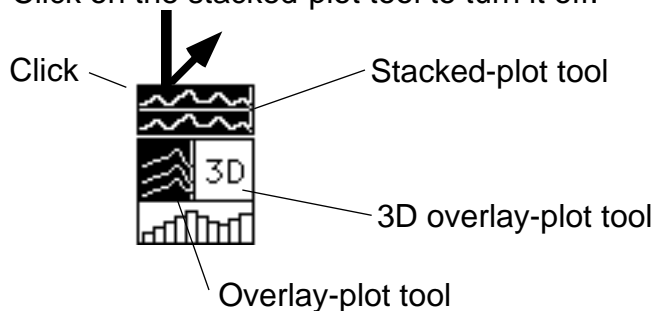
- Click OK. The spectrum curves will be redrawn with wavelength values at the same X axis locations for all curves:



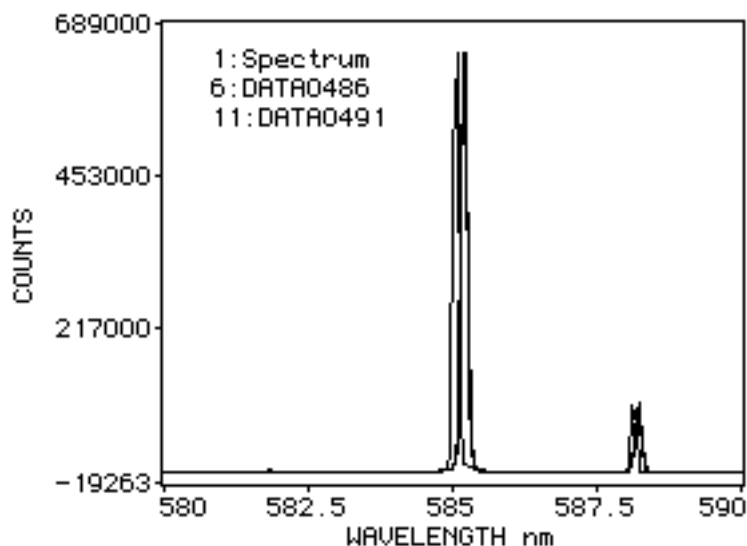
"Linearize X" makes all plot X axes "lock in" to the specified X Min and X max values.

Change the stacked plot to a 2D overlay plot:

- Click on the stacked-plot tool to turn it off:



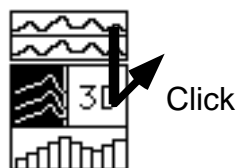
This puts the display in **2D overlay-plot mode**:



The 3 spectra are now plotted in the same area with the same axes. Since "Linearize X" is in effect, the spectral peaks of the same wavelength are superimposed. (The slight mismatch between peak locations, on the order of ± 0.2 nm, gives an indication of the accuracy of the calibration used by this file.)

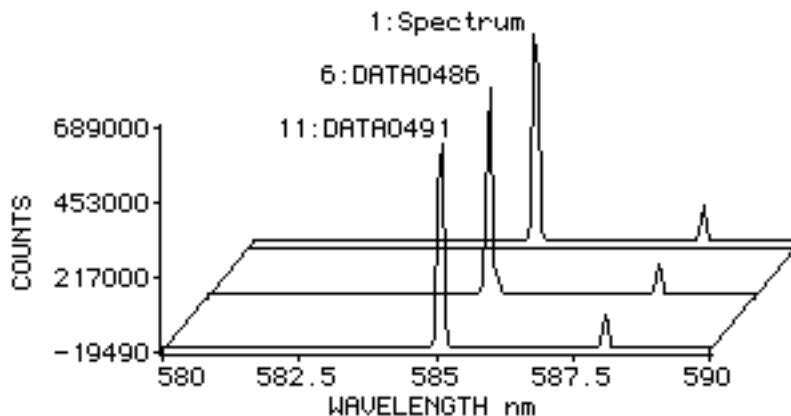
Change the 2D overlay plot to a 3D overlay plot:

- Click in the 3D overlay plot tool. This puts the display in **3D overlay plot mode**.

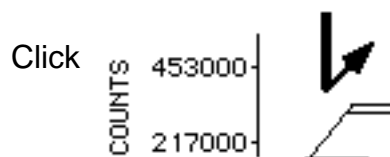


(If the 3D plot is not entirely inside the display window, select the *Set:Reset Plot Layout* menu to make it fit.)

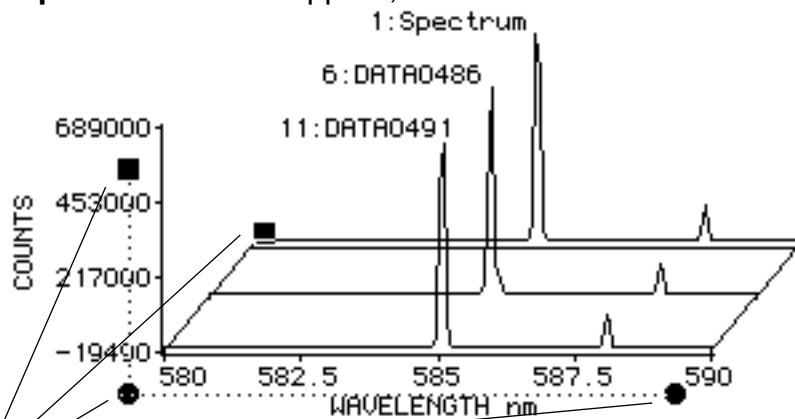
3D Overlay Plot



- Click once in the display window and hold the mouse button down.

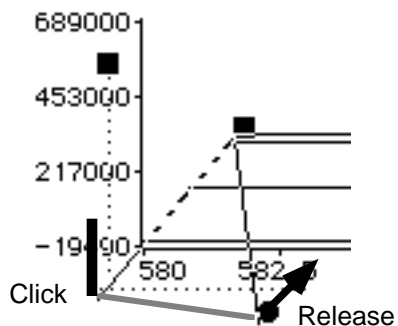


The **3D plot handles** will appear; release the mouse button:

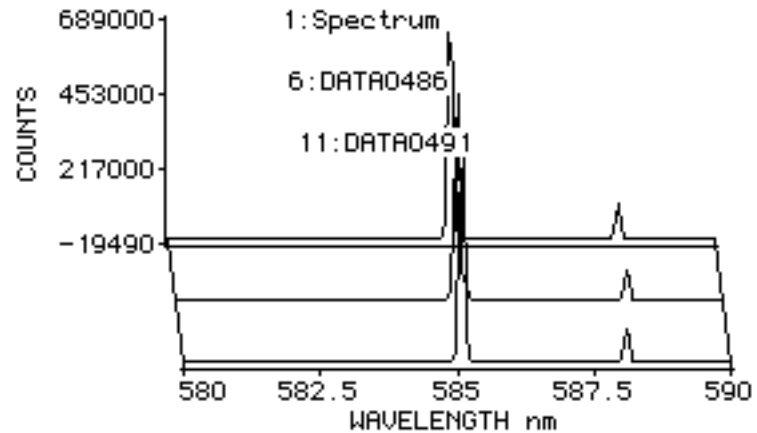


3D plot handles

- Drag the front 3D plot origin (round dot) a small distance to the right.



The 3D plot will be redrawn to a new perspective:



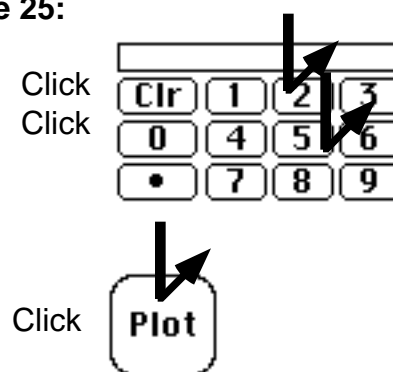
(The other handles can be dragged to change the size of the 3D plot.)

- Turn off overlay-plot mode by clicking in the 2D overlay-plot tool:

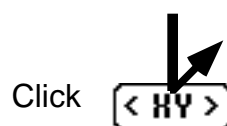


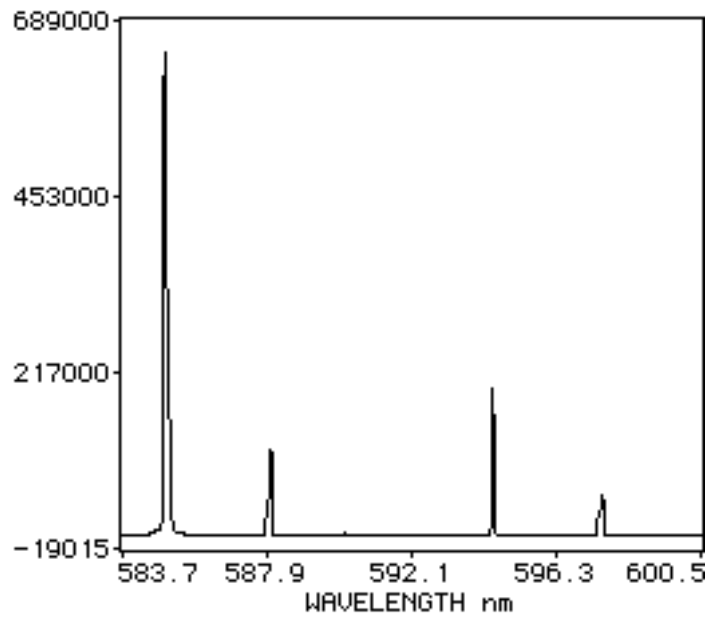
(Now only one spectrum should be plotted in the display window.)

- Plot spectrum curve 25:

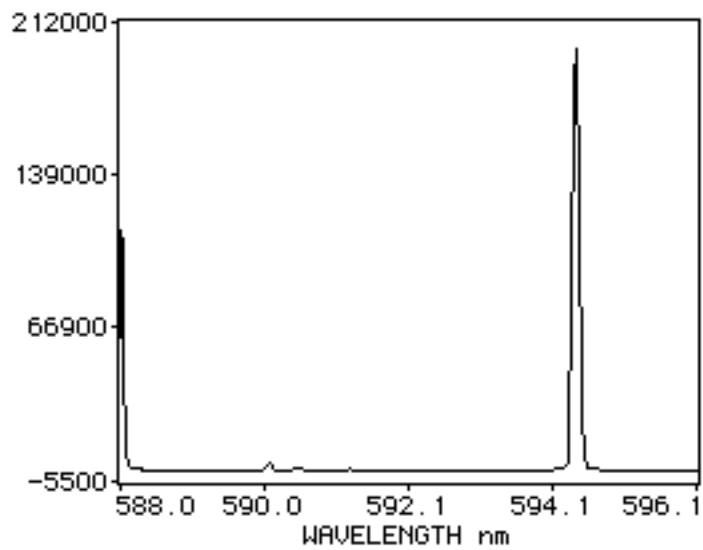


- Click the XY autoscale button:



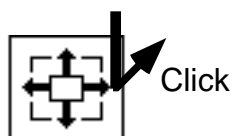


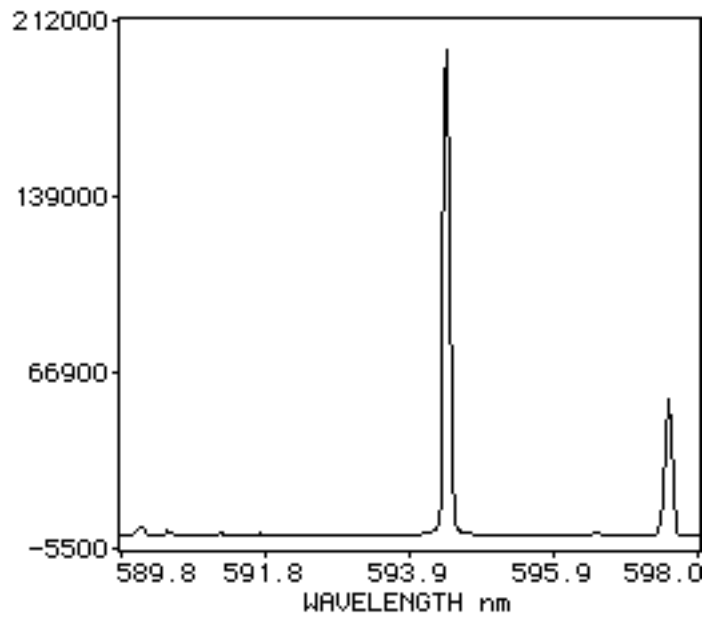
- Click in the X-zoom tool. The plot will zoom in X.



(The Y axis scale changes if 'Auto Y Scale' is enabled.)

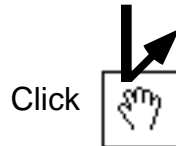
- Click on the right side of the XY zoom tool. The plot will pan to the left.



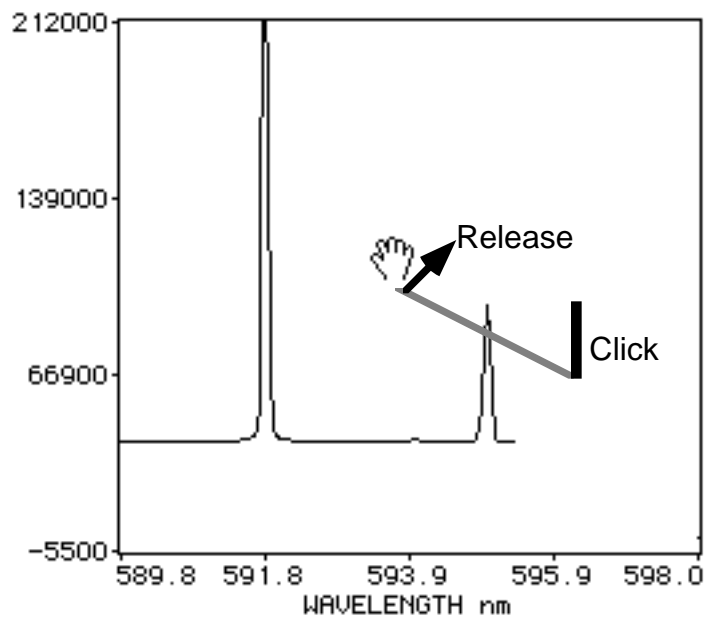


Using the dragging hand tool:

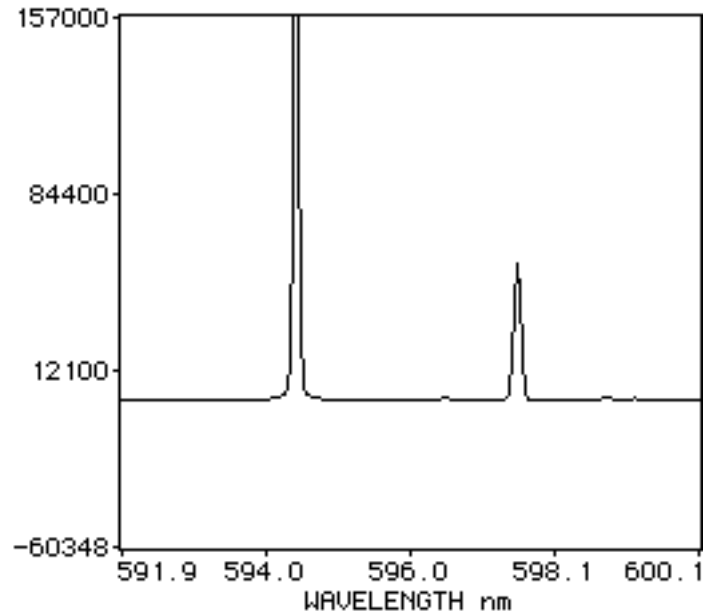
- Click in the dragging hand tool to turn it on:



- Move the pointer to the plot window area. The pointer turns into a hand indicating it is ready to drag the plot. Click in the plot and drag it a short distance as shown.



After you finish dragging the plot, it will be redrawn so that the curve is in the new location. The plot axes are updated accordingly.



- Turn off the dragging hand tool:



Editing spectrum points:

- Select the *Set:General Settings* menu:



KestrelSpec Settings

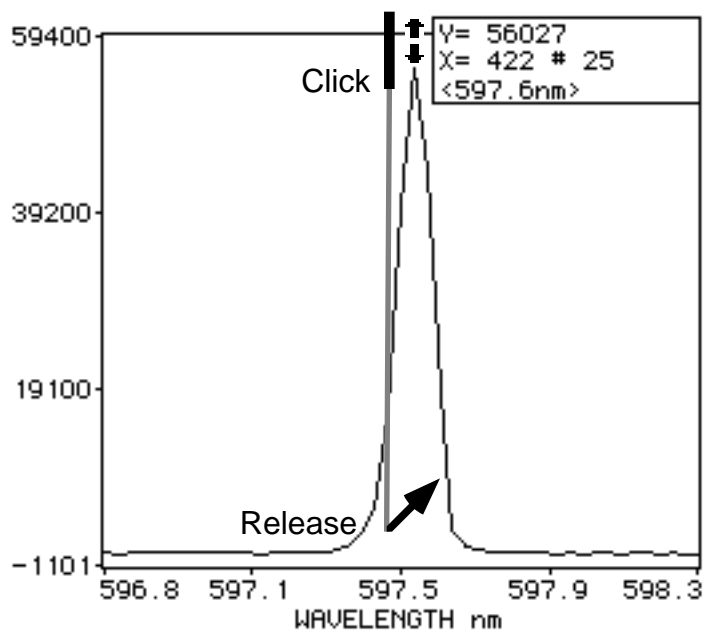
- Click on 'Auto <Y> Scale' to turn it **off**.



- Click OK.
- Click on the **point editor tool** to turn it on:

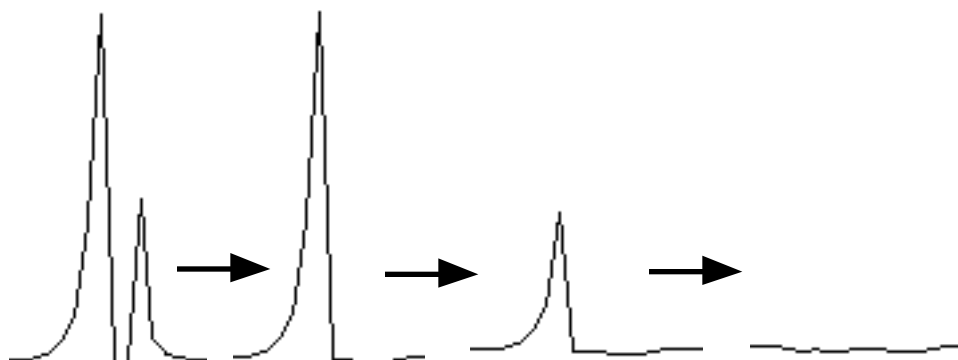


- Move the pointer to the plot window over a peak. Drag the peak down so that the point is at the base line level:



(To cancel the editing of a point, select the *Edit:Undo* menu.)

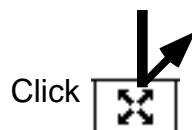
- Repeat the "drag down" process for the other points in the peak:



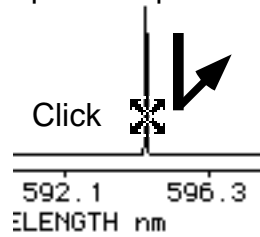
(Of course we recommend you only edit data for valid scientific purposes, e.g. for cosmetic removal of a known noise peak.)

Using the quick-zoom tool:

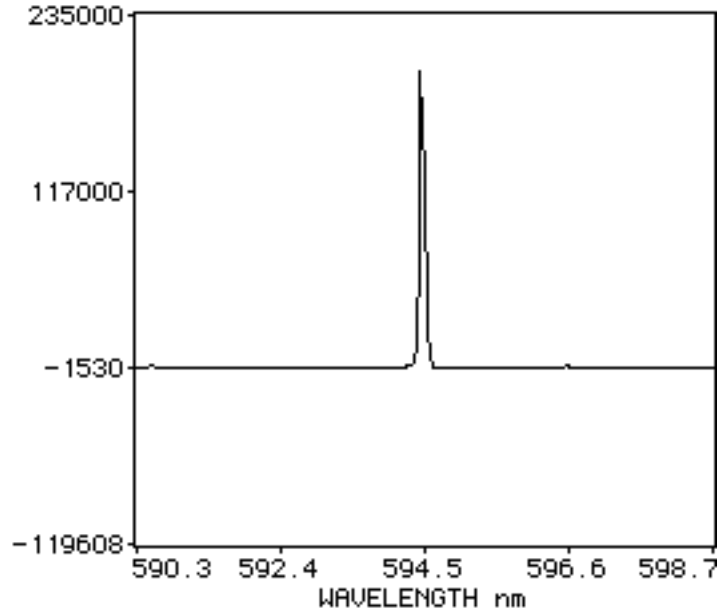
- Click in the quick-zoom tool to turn it on:



- Move the pointer so that it is centered over a region of interest in the spectrum plot. Click the mouse.

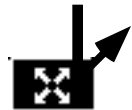


The plot will zoom-in by a factor of two in both X and Y:



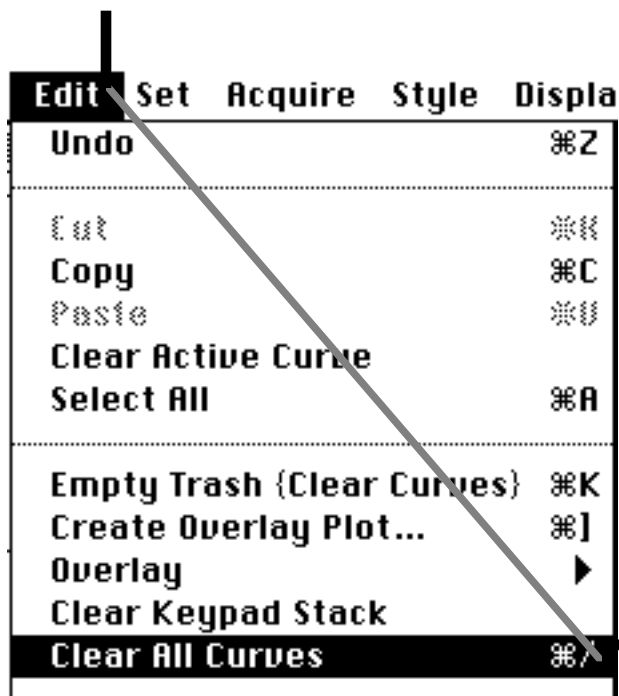
(The plot will zoom out if the *option* key is down.)

- Click again on the quick zoom tool to turn it off: Click



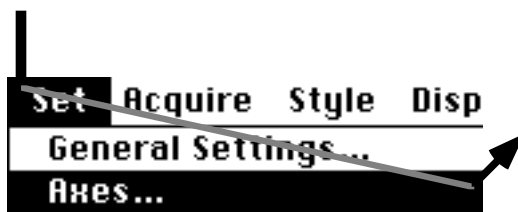
- Choose the *Edit:Clear All Curves* menu to erase all spectra.

A caution alert window will appear, click OK to confirm the clear.



Performing curve arithmetic:

- For faster plotting, select the *Set:Axes* menu and turn off "Linearize X."



Click **Linearize X** to turn it off.

- Select the *File:Open* menu:

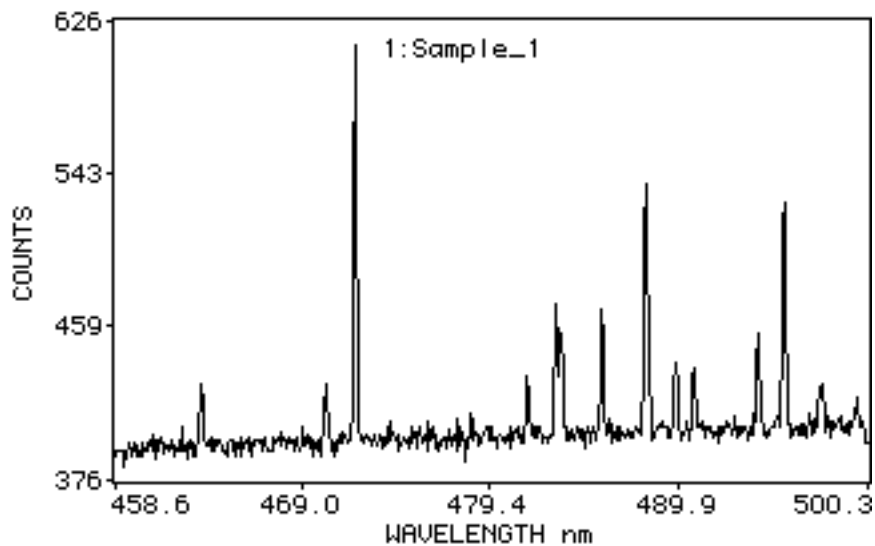


- Open the "Sample Curve Data" file:

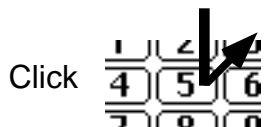


- Click the <XY> autoscale button.

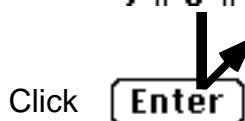
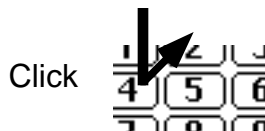
The display window should look like this:



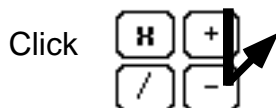
- Click the **5** button, then the **Enter** button:



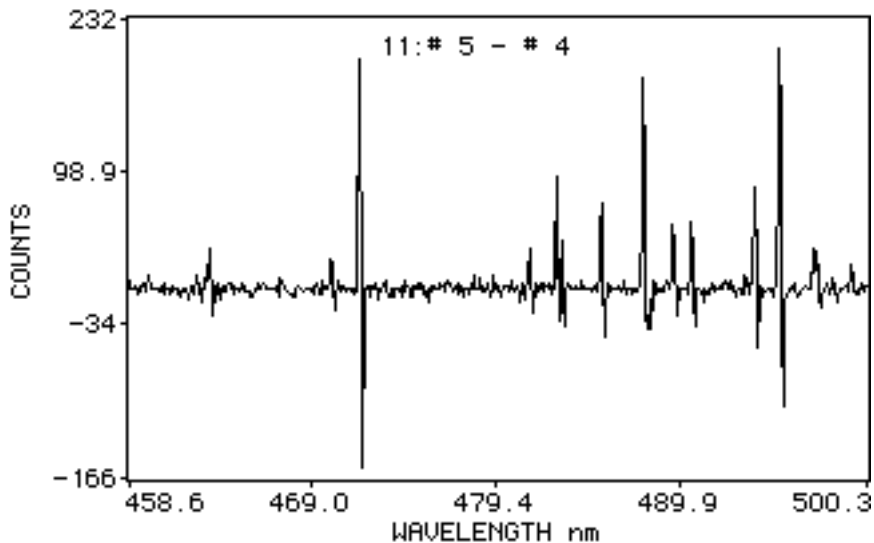
- Click the **4** button, then the **Enter** button:



- Click the - (minus) button:



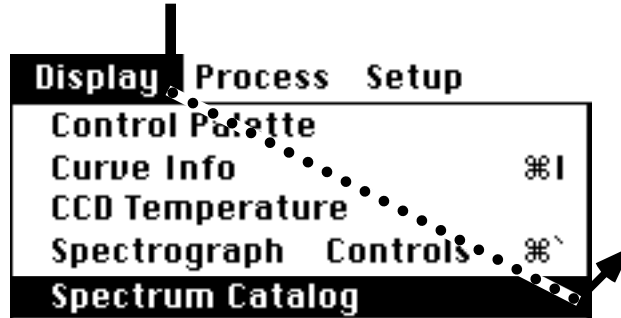
Curve 4 will be subtracted from curve 5, and the result will be put in the next available RAM curve memory (# 11 in this case).



Other dual-operand curve math (+,/,*) operations work in a similar manner. Single-operand operations (log, abs) will use the active curve unless a curve number is entered on the keypad.

Using the spectrum catalog:

- Select the *Display:Spectrum Catalog* menu:

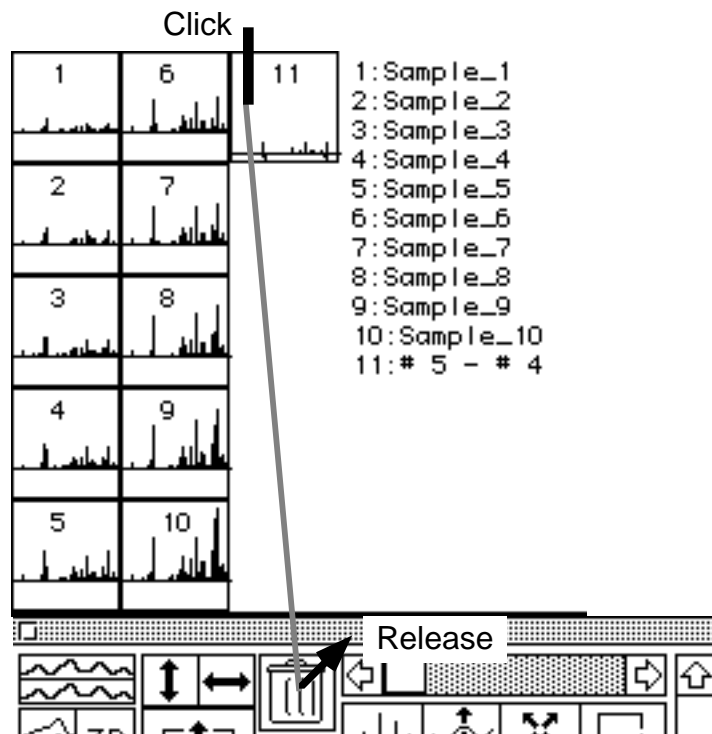


- Click the <XY> autoscale button:



The display window will show the **spectrum catalog**, which has a scrollable view of up to 40 "mini" spectrum plots at a time. You can cut, paste, clear and "open" the mini-plots in ways similar to the icons on the Macintosh desktop.

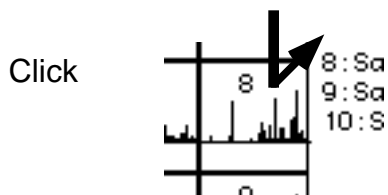
- Clear curve 11 by dragging its mini-plot to the spectrum trash can:



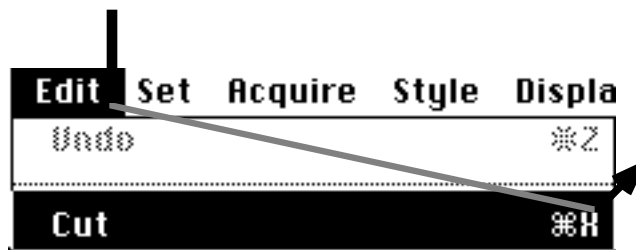
- To finish the clearing, select the *Edit:Empty Trash* menu. (To select more than one mini-plot at a time for dragging to the trash, hold down the *shift* key and click once on each mini-plot.)

Cutting and pasting spectra in the catalog:

- Click once on the mini-plot for curve number 8:



- Curve 8 is now the active curve, and it will flash.
- Select the *Edit:Cut* menu:



The mini-plot for curve 9 moves into the position formerly occupied by curve 8.

- Click once on the mini-plot for curve number 3 to select it:

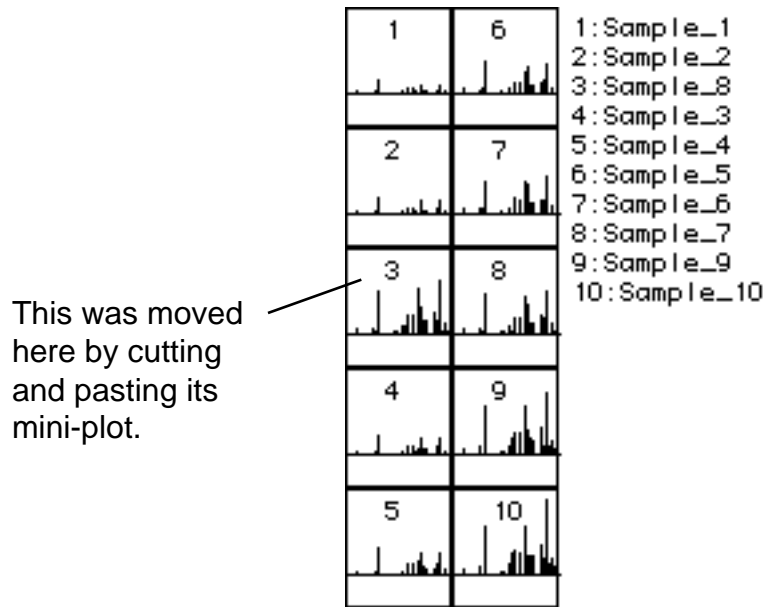


- Select the *Edit:Paste* menu

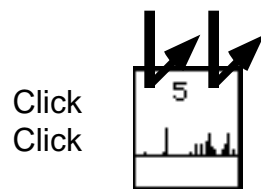


The mini-plot for the previously-cut curve will be inserted into curve memory number 3, pushing the other curves up by one memory location to make room.

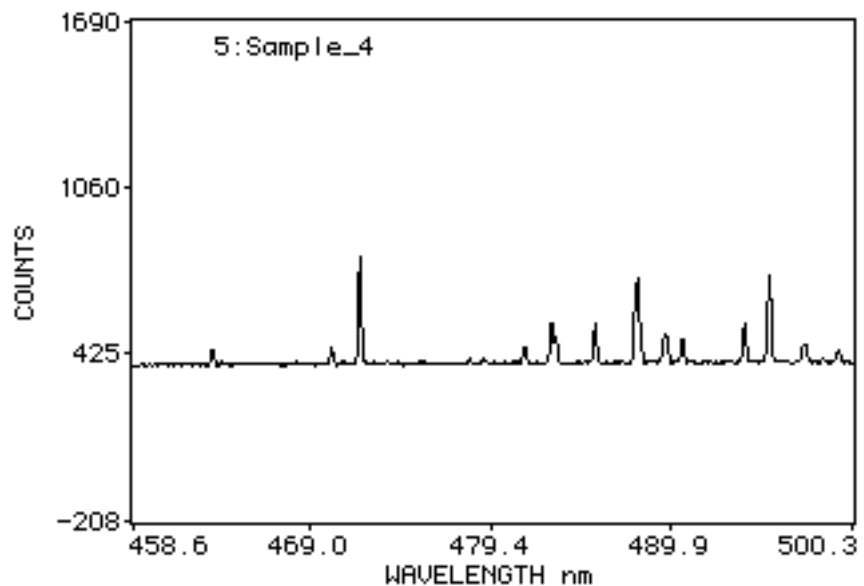
The edited spectrum catalog has the spectrum that was originally in position 8 now occupying position 3:



- Select a mini-plot in the spectrum catalog for plotting:
- Double click on mini-plot number 5:

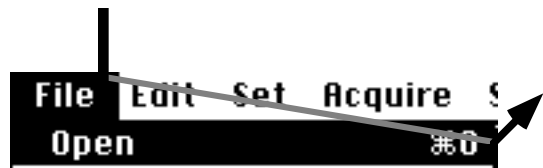


- The normal plot window display will appear with the selected spectrum:



Open an image file:

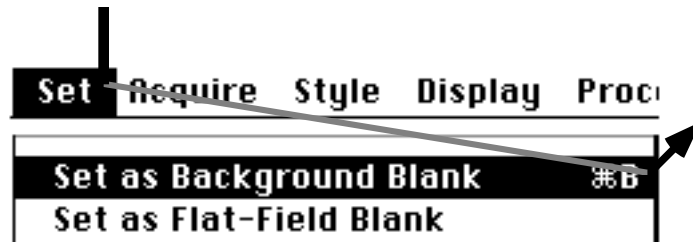
- Select the *File:Open* menu:



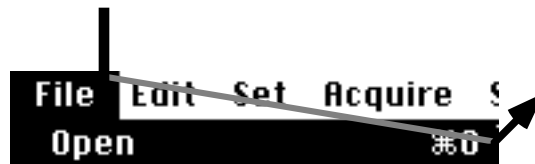
- Double-click on the "Background image for Raman" file:



- Select the *Set:Set as Background Blank* menu:



- Again select the *File:Open* menu:



- Double-click on the "Raman image DMSO 632.8 nm" file:



(An alert may ask if you want to clear existing image(s). Click **Yes.**)

The "Raman image" file will now be shown in the display window.

Image-Pixel Readout

- Move the pointer over the image display. The pixel location and intensity value are shown in the upper left area of the control palette.

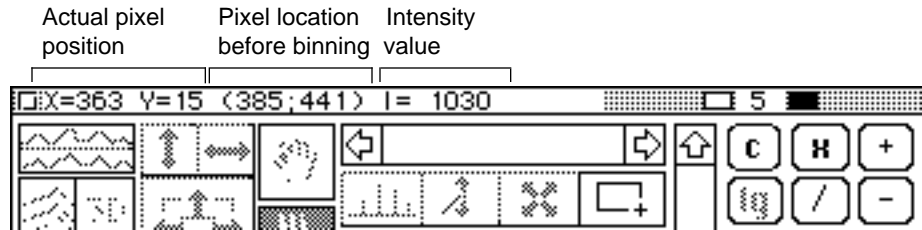
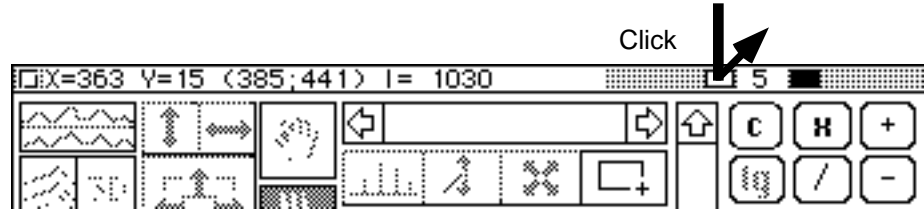


Image Brightness Control

- Click in the small white rectangle in the top middle of the control palette (this changes the image display brightness):



- The image display is updated. The intensity scale (color-code) at the right side of the display will have values that are one-half the previous settings.

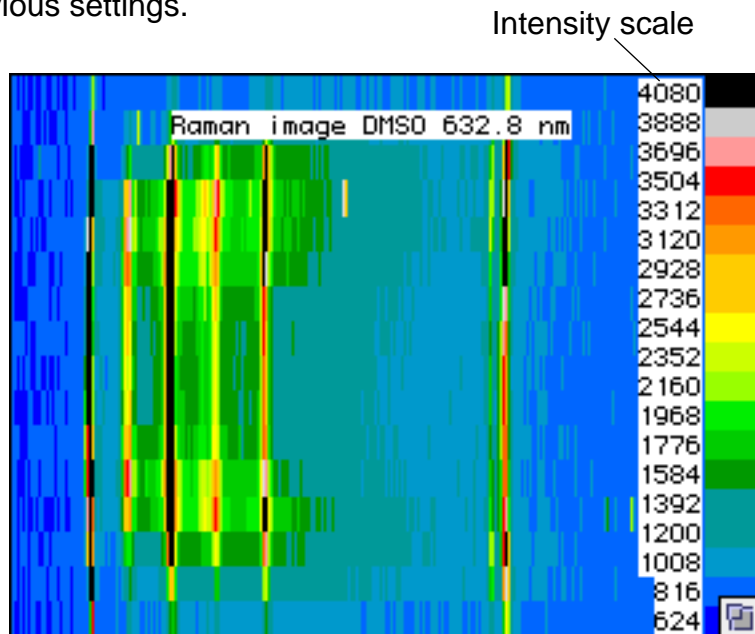


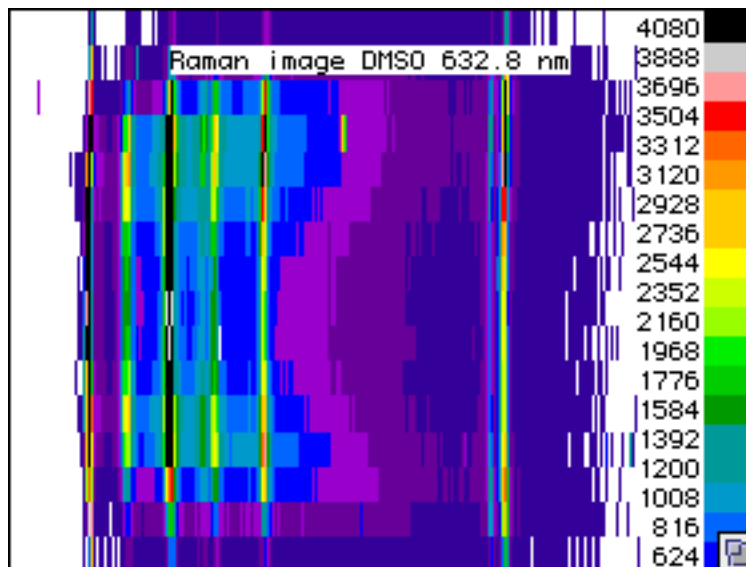
Image Arithmetic

Subtract the background image:

- Click the - (minus) button:



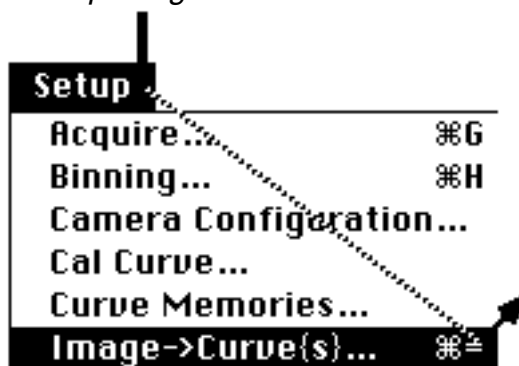
After subtracting the background, the image display will look like this:



Making Spectra from the Image

Make spectra from the image:

- Select the *Setup:Image->Curves* menu.



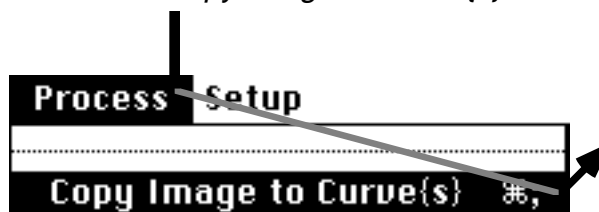
- Type "4" in the top edit field of the window that appears.

Image->Curve(s)

Image-> **4** curve(s)

This assigns the top one-fourth of the image rows to the 1st curve, the next one-fourth of the image rows to the 2nd curve, etc.

- Click OK.
- Select the *Process:Copy Image to Curve{s}* menu:



- Click the Plot button (or *return* on the keyboard).

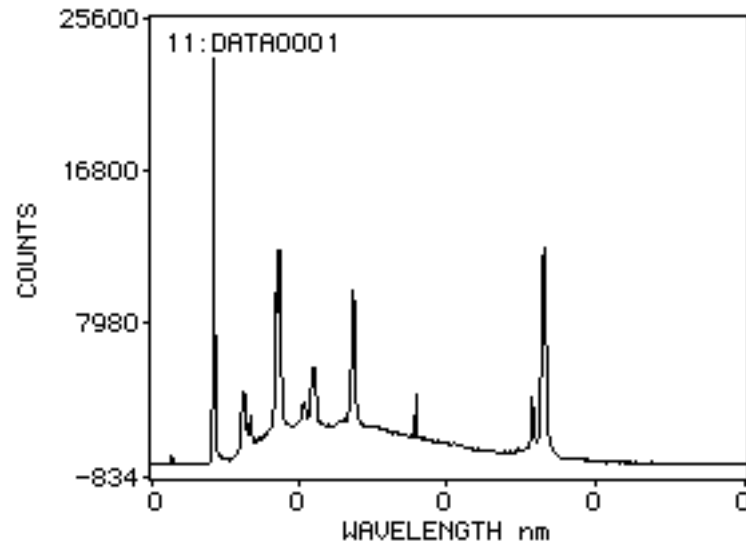
Click



- Click the <XY> autoscale button.

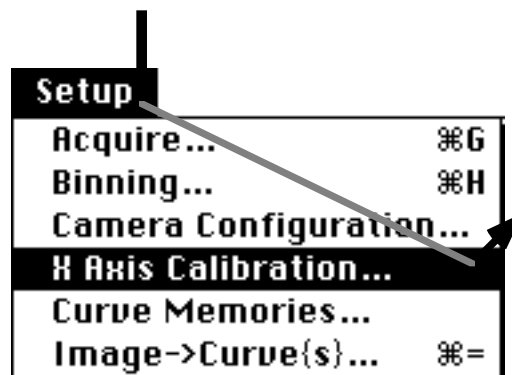


- The display window shows the first of the 4 spectrum curves you made from the image. The wavelength values are 0 because there is no calibration set up for this spectrum yet.



Calibrating Spectra with a Calibration Curve

- Select the *Setup:: X Axis Calibration* menu:



- In the window that appears, type the values shown in the first four edit fields. Turn on the two 'Select' buttons as shown.

Select:	Pixel	Value
<input checked="" type="checkbox"/>	77	632.8
<input checked="" type="checkbox"/>	362	777.7

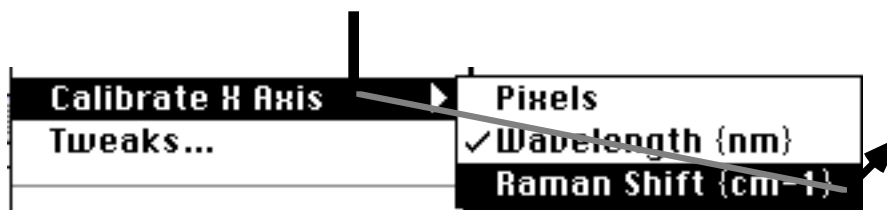
- In the "Laser Line" field type the value shown:

Laser Line (nm)

- Click the 'Update Cal Curve' button.



- Click OK.
- Select the "Style:Calibrate X Axis:Raman Shift {cm-1}" menu.



The spectrum plot X axis will now be calibrated according to the information you have provided:



(A "real" calibration curve would usually require more than two reference pixels, since spectrograph wavelength dispersion is not perfectly linear.)

**Laser-Beam
Profiler
Display**

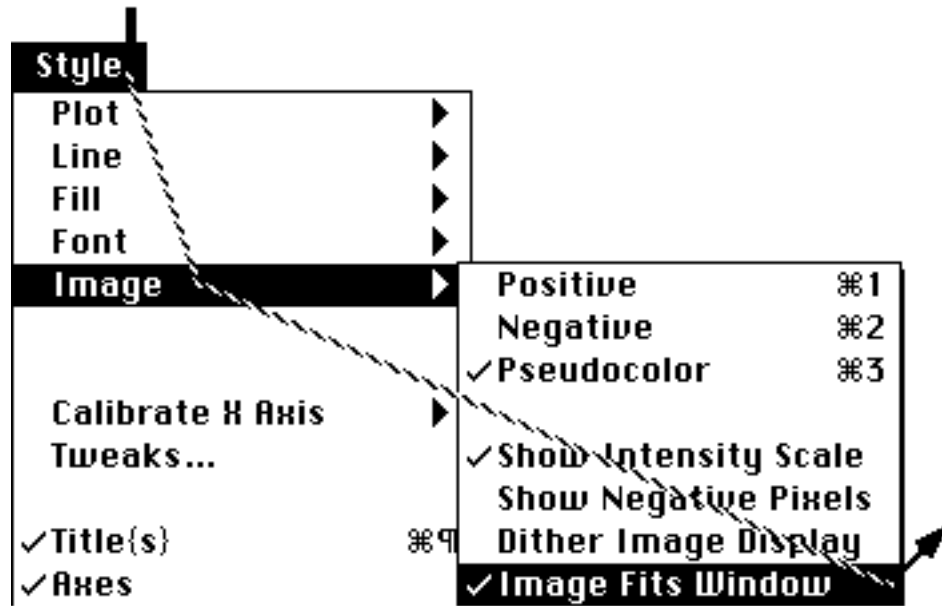
- Again select the *File:Open* menu:



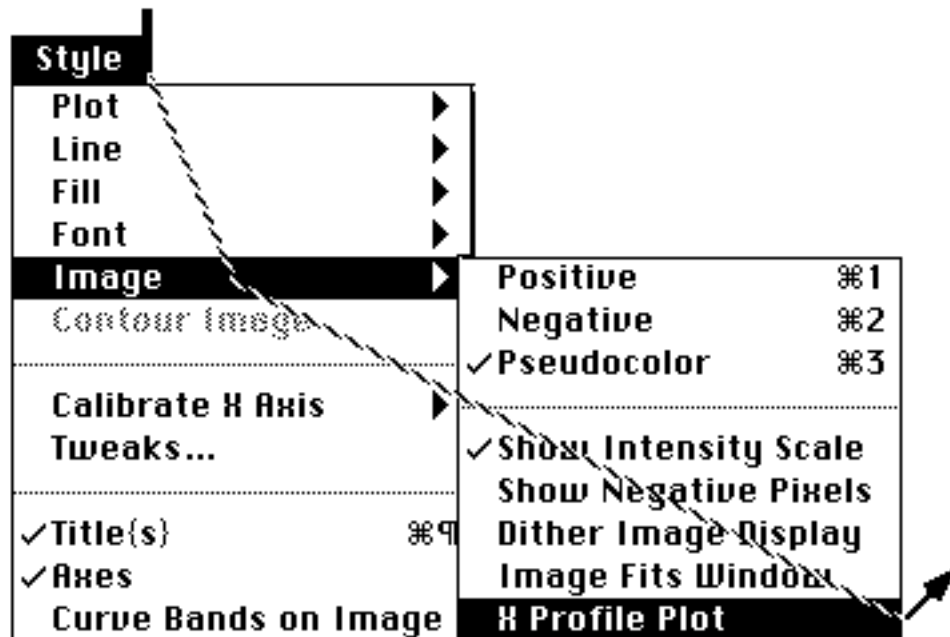
- Double-click on the file "Laser Profile Image" to open it:



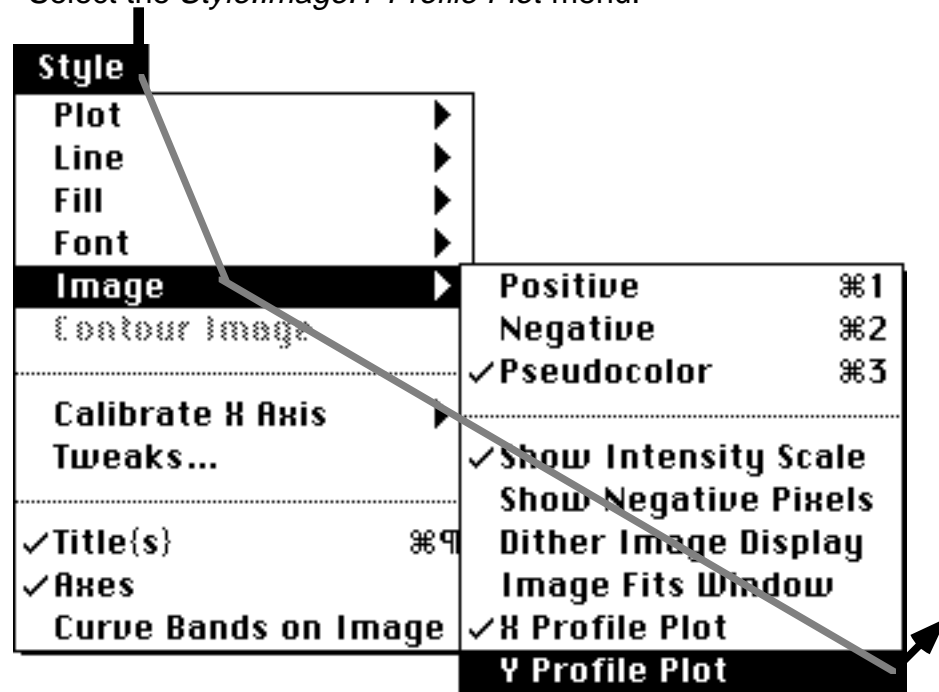
- Select the *Style:Image:Image Fits Window* menu to toggle it off:



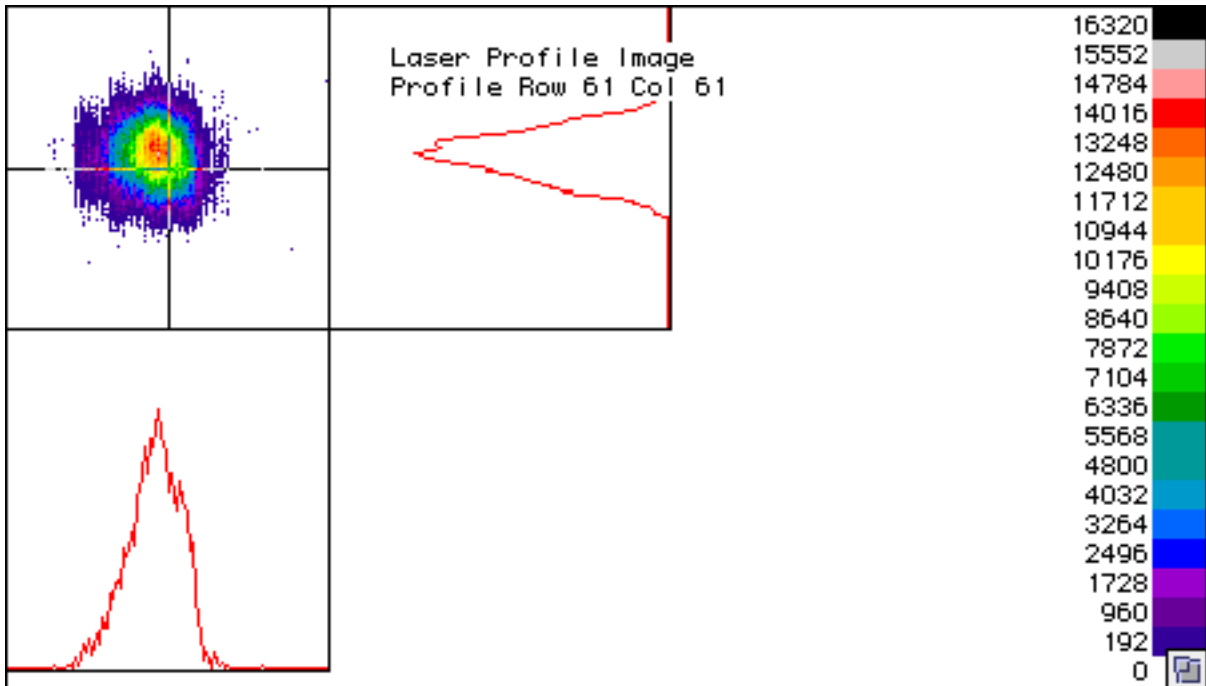
- Select the *Style:Image:X Profile Plot* menu to toggle it on:



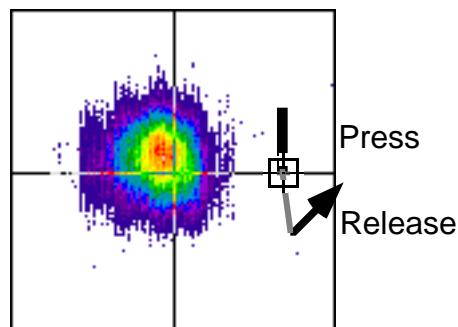
- Select the *Style:Image:Y Profile Plot* menu:



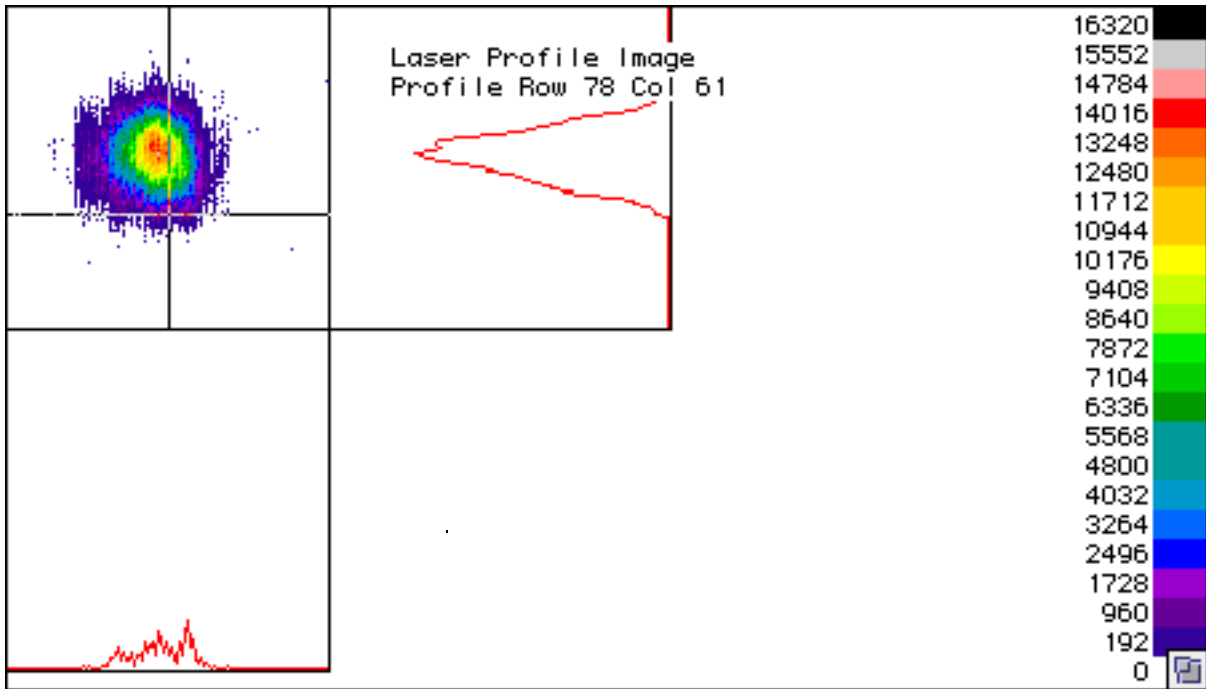
- The display should now look like this (profile lines may be different):



- Click on the horizontal profile line and drag it a small distance:



The display will update to show the new profile row position:

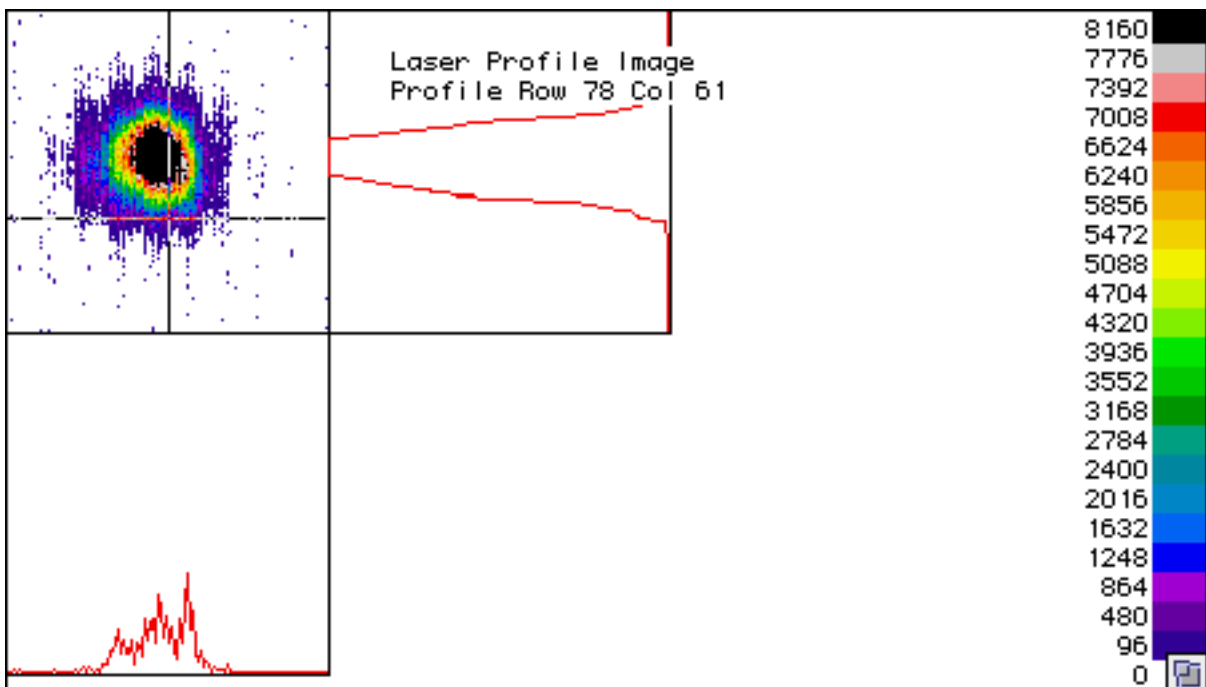


The profile plots have intensity scales that range between 0 and the maximum value shown on the color legend.

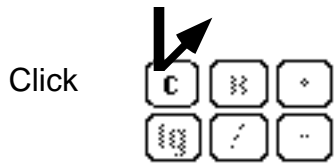
- Change the scale of the display by clicking once in the white brightness-control rectangle in the control palette:



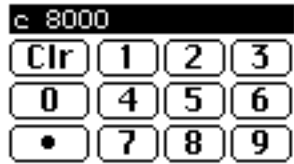
The intensity scale changes to 1/2 the former range:



- Click in the "c" (constant) button:



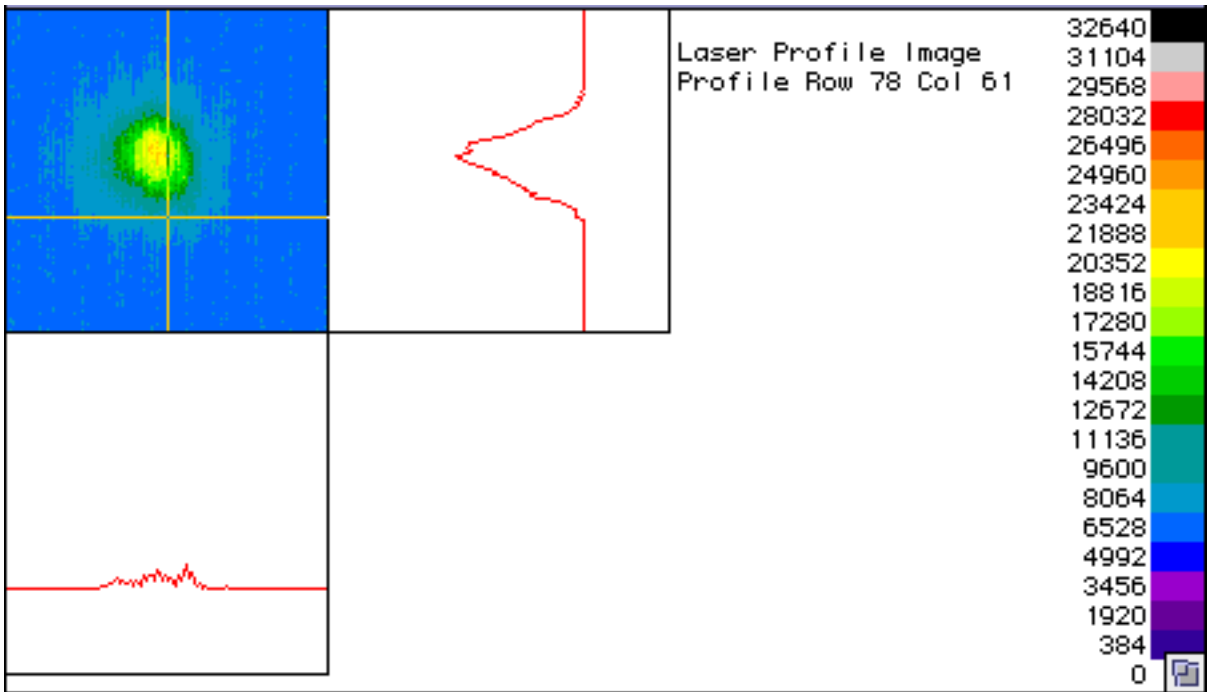
- Type 8000 on the keypad



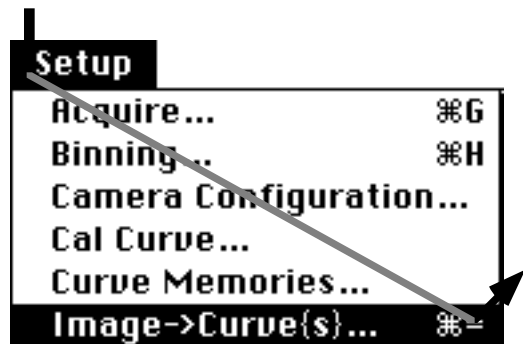
- Click in the "+" (add) button:



This adds the constant value of 8000 to every pixel in the image. The display is updated to show the changed image:



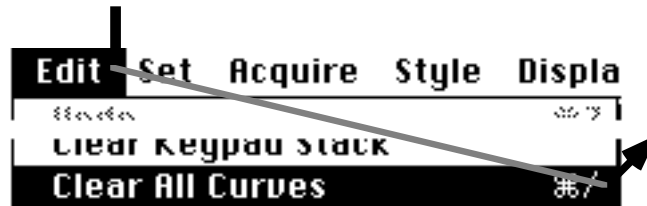
- Select the *Display: Active Image* menu to reset the automatic display brightness.
- Select the *Setup: Image->Curve(s)* menu:



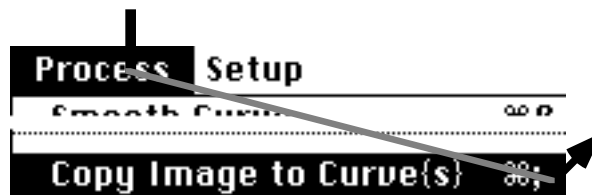
- In the dialog window, type **10** for the number of curves.

Image→ curve(s)

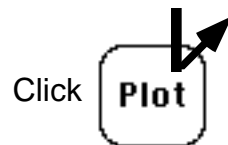
- Click OK.
- Select the *Edit:Clear All Curves* menu.



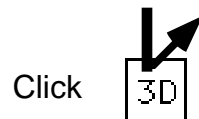
- Select the *Process:Copy Image to Curve{s}* menu:



- Click the Plot button:



- Click the 3D button:



- The values in the dialog window should be as shown below.
Click OK.

Curves in Overlay Plot

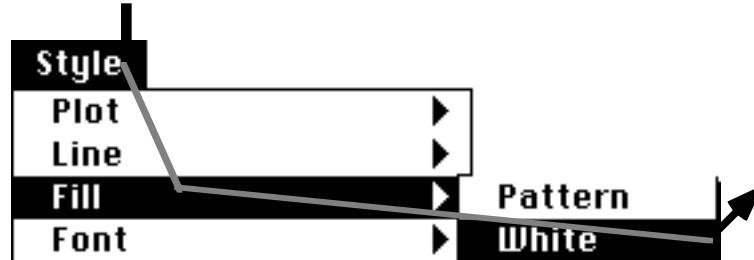


- (The 3D plot may not fit inside the display window if you have changed the window size. In that case, select the *Set:Reset Plot Layout* menu to automatically make the plot fit the window.)

- Click the <XY> button to autoscale the 3D plot:



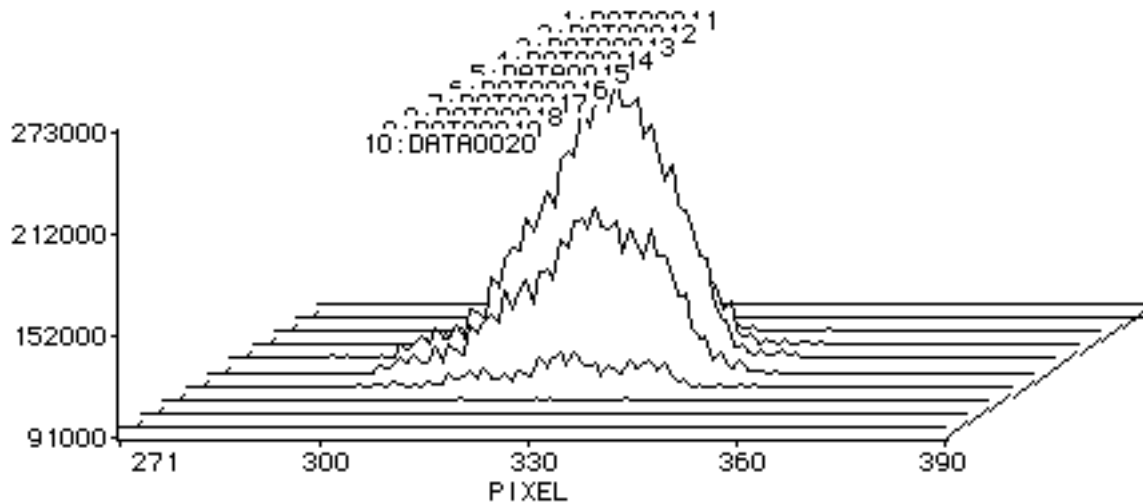
- Select the *Style:Fill:White* menu:



- Select the *Edit:Create Overlay Plot* menu. Click OK in the dialog window. (This redraws the 3D plot with the fill color you selected.)



- The 3D plot should now look like the one below, with "hidden lines removed."

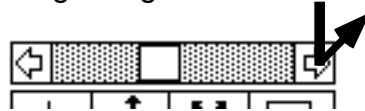


- Click in the channel-profile plot tool:

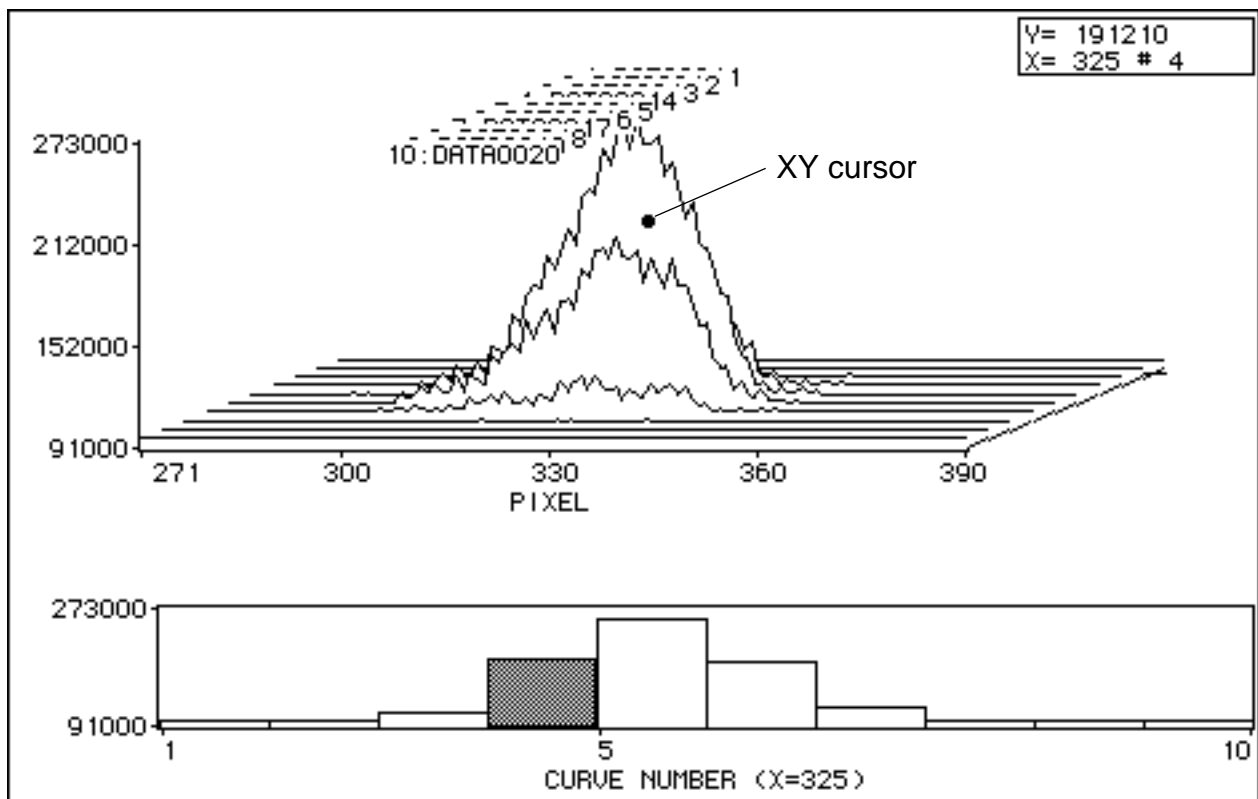


The channel-profile plot will be drawn below the 3D plot.

- Click in the X cursor scroll bar until the XY cursor (small dot ●) is in the middle of the 3D plot. Notice the channel profile bars change height as the cursor is moved to different X positions.



- The plot display should look similar to that shown below:

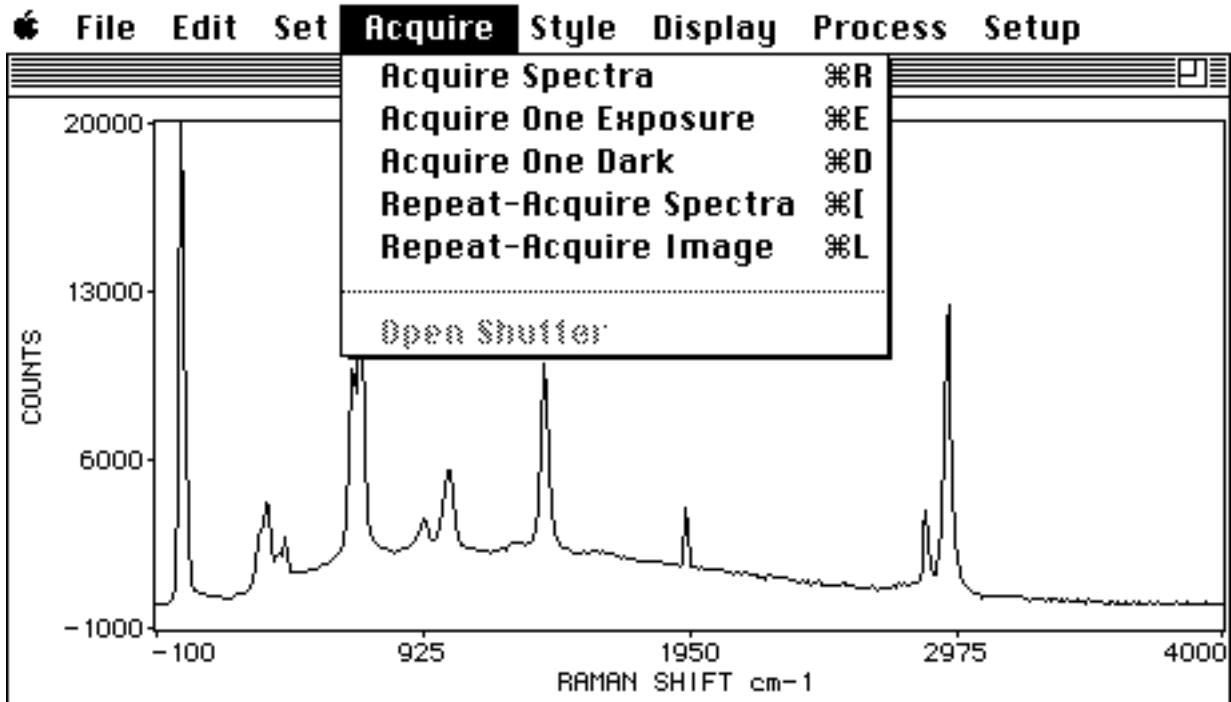


The highlighted bar in the channel profile shows the active curve.
(You can use the Z scroll button to select a different active curve.)

- To return the display to single-curve plot mode, click in the overlay plot tool to turn it off:



Chapter 2: Using KestrelSpec



Setting Up to Acquire Data with the Kestrel Macintosh ST-6I CCD Camera

⇒ Slower Macs may need to have AppleTalk turned off when you are running the CCD to prevent unrecoverable data-transmission problems. (KestrelSpec presents a special dialog if a data error occurs.) This is more likely to happen if the CCD baud is set above the default speed (19200). Current Macs usually enable KestrelSpec to reliably operate the CCD at 57600 baud with AppleTalk turned on.

- Mount the ST-6I camera head on your spectrograph. Spectrograph manufacturers offer (or can make) a custom mounting adaptor for the ST-6I. Some spectrographs can also be had with C-mount adaptors, which may be used with a C-mount threaded plate for the ST-6I available from Santa Barbara Instrument Group. Contact SBIG if you need detailed camera-mounting specifications or drawings.

- Place a spectral-line source (Hg lamp, fluorescent lamp, neon lamp, etc.) in front of the entrance slit of the spectrograph.

- Connect the cables to the ST-6I camera head and controller. Connect the RS-232 cable between the "COM" port on the controller and the modem (telephone) port on your Macintosh. Turn on the power switch on the ST-6I controller.



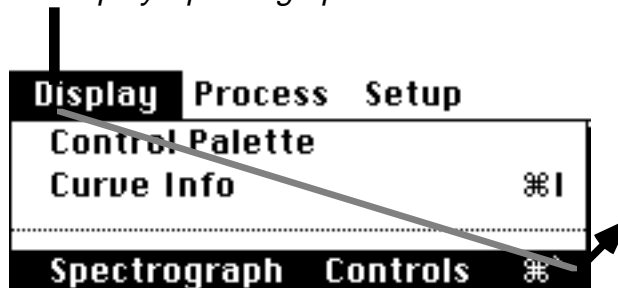
⇒ • Open the "Chooser" under the Apple menu. If the printer is using the modem port, switch it to the printer port (click on the printer icon so that it is highlighted as shown at left).

Connecting the Spectrograph Computer Interface

- If you do not have the KestrelSpec spectrograph control option skip to "Focusing the System" on the next page.
- If your version of KestrelSpec has the spectrograph control option, connect the serial cable from the "host computer" port on the spectrograph to the printer port on the Macintosh. Turn on the spectrograph power.

⇒ AppleTalk cannot be used when the spectrograph is connected to the Macintosh printer port. If your spectrograph has a GPIB (IEEE-488) interface that is supported by KestrelSpec you can use it to connect to the Macintosh via a National Instruments Macintosh GPIB interface. (See the *Reference* section of this book for details on setting up the GPIB spectrograph interface.)

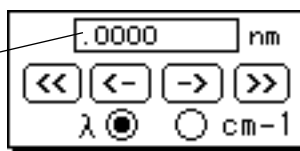
- Select the *Display:Spectrograph Controls* menu:



Spectrograph Computer Interface

The spectrograph extension to the control palette will appear.
Type the desired wavelength into the edit field shown:

Double-click
in this edit field,
then type the
wavelength.



Click the **Set**
button (or
enter on
the keyboard)



The spectrograph will then change to the desired wavelength.
(Use the <- or -> button to make small wavelength changes,
use the << or >> button to rapidly scan wavelength.)

Focusing the System

- If KestrelSpec is already running, Quit it, trash any PREFS file you may have created, and reopen KestrelSpec. This insures that all settings are in their default state.
- If you have not already done so, adjust the spectrograph wavelength setting to correspond to the location of spectral line(s).
- Select the *Set:Auto Background Subtraction:Dynamic* menu.
- Select the *Acquire:Acquire Spectra* menu.
If this is the first time the system has been operated since power on, a window will appear showing the status of the automatic video offset adjustment.
- The CCD is exposed and read out in the default (750x30) binning mode. (This will take about 10 seconds.) By default, the entire image will be used to create a single spectrum curve.
- Examine the data. If the spectral lines don't appear, move the source closer to the spectrograph entrance slit or increase the exposure time (use the *Setup:Acquire* menu). Do the opposite if the lines are saturated or the data is a constant, large value.
- Select the *Acquire:Repeat-Acquire Image* menu. Adjust the camera head position and rotation so that the spectral line images are perfectly vertical and as narrow as possible.
- Click the STOP button (or *return*) when finished.

Acquiring Data

Acquire	Style	Display	Proc
Acquire Spectra			⌘R
Acquire One Exposure			⌘E
Acquire One Dark			⌘D
Repeat-Acquire Spectra			⌘[
Repeat-Acquire Image			⌘L

Open Shutter			

- All data acquisition is performed using the "Acquire" menu.

Acquire Spectra does a "complete" data-acquisition procedure as specified with the *Setup:Acquire* menu (using the no. of accums., no. of scans, etc).

Acquire One Exposure is the same as *Acquire Spectra*, except it only does one "scan," and spectrum curves are not automatically created when the display is in image mode. Control of the software is returned to you if the exposure time is more than a few seconds, so that you can work on other things while waiting.

Acquire One Dark is the same as *Acquire One Exposure*, except the camera shutter is kept closed and automatic dark-background subtraction is disabled.

Repeat-Acquire Spectra continuously repeats the equivalent of *Acquire One Exposure* and displays the data as spectrum plots. (Press the STOP button, the *return* key, or command-period to halt the process.)

Repeat-Acquire Image is the same as *Repeat-Acquire Spectra*, except that the data is displayed as an image instead of as spectrum curves.

Open Shutter /Close Shutter is available in case you need to manually open or close the camera shutter at any time. (Shutter operation during data acquisition is completely automatic.)

- You can wire the Macintosh mouse switch to an output from your experimental apparatus for synchronization. The system will wait for a mouse-button click before proceeding if you hold down the *option* key on the keyboard when selecting an *Acquire* menu item. Hold down *shift* and *option* to make the system start data acquisition when the Macintosh internal clock reaches the next second. (Another method is to use *KestrelScript* commands from LabView® or other program.)

Setting Up for Data Acquisition

- Data-acquisition parameters are set using the *Setup:Acquire* menu

Acquire Setup

Exposure Time	0.1
No. of Accums.	1
Delay/Accum (s)	0
Start Mem. No.	AUTO
No. of Scans	1
Delay/Scan (s)	0

Control Spectrograph:

Wavelength at 1st Scan nm μ m
500

Wavelength Step Per Scan 0

Spectrograph wavelength controls
(with spectrograph control option).
Automatically positions spectrograph wavelength at start of acquisition and steps the wavelength by the indicated amount for each scan after the 1st.

New Curve Name:
DATA

New Image Name:
IMAGE

Cancel OK

Acquire parameters

- **Exposure Time** is set in seconds, in 0.01 second increments.
- **No. of Accums.** is the number of exposures that will be co-added into spectrum curve(s)
- **Delay/Accum (s)** is the time, in seconds, that the system will pause between accumulation exposures. (Delay resolution is 1/60 second.)
- **Start Mem. No.** is the starting curve memory that will be used for spectrum data during data acquisition. <AUTO> indicates that the next available free curve memory will be used, and old data will thus not be cleared.
- **No. of Scans** is the number of times that the Accum. cycle will be repeated.
- **Delay/Scan (s)** is the time, in seconds, that the system will pause between scans.
- **New Curve Name** and **New Image Name** are the root names to which an index number is added for each data acquisition.

Setting Up Binning of CCD Image

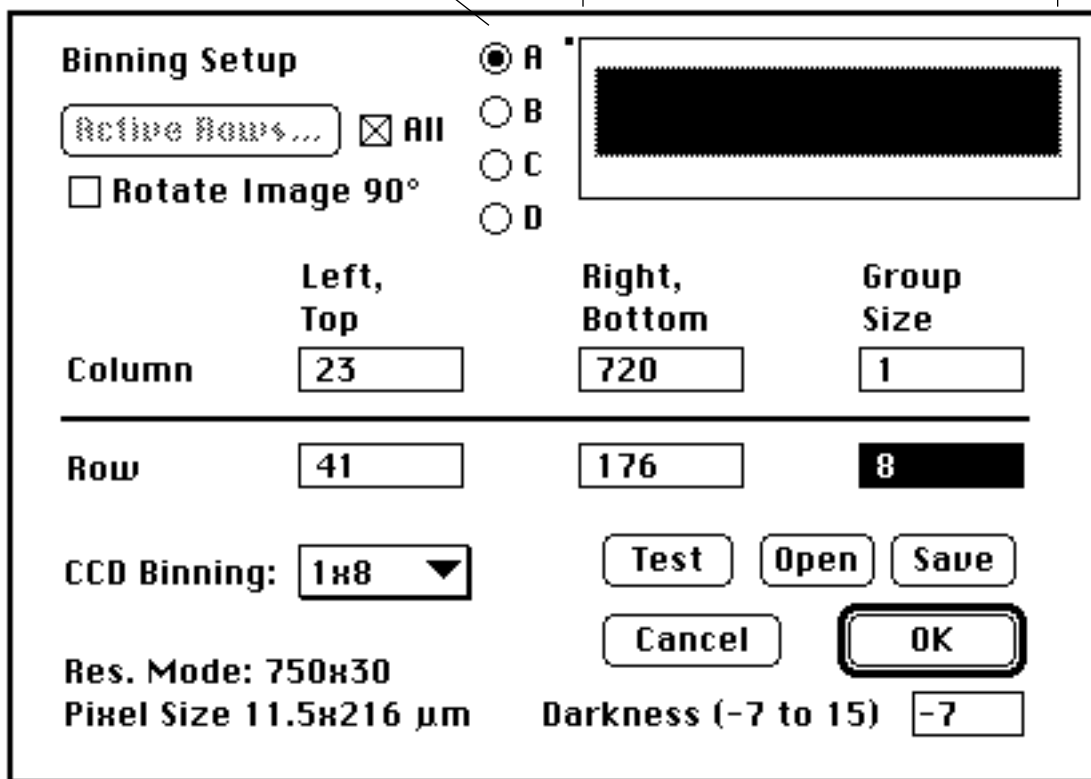
"Binning" in imaging spectroscopy refers to the the setting up of the way the image is read out from the CCD sensor.

- To setup binning, select the *Setup:Binning* menu:



"Radio" buttons select from 4 different pre-set binning formats

Green rectangle shows readout area of CCD



Use the pop-up menu to select ST-6l group-size (summation of pixels) mode

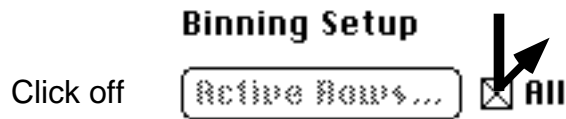
- **Test** checks the row and column numbers and rounds them off to multiples of the group size.
- **Open** and **Save** enable saving and restoring binning formats from disk.
- **Darkness** sets the image-display darkness setting.



- Only a single image subarray ("stripe") will be used if the **All** button is turned on. (You can make multiple spectra from a single subarray using the *Setup:Image->Curve{s}* menu.)

Setting up Multiple Image Subarrays (Stripes)

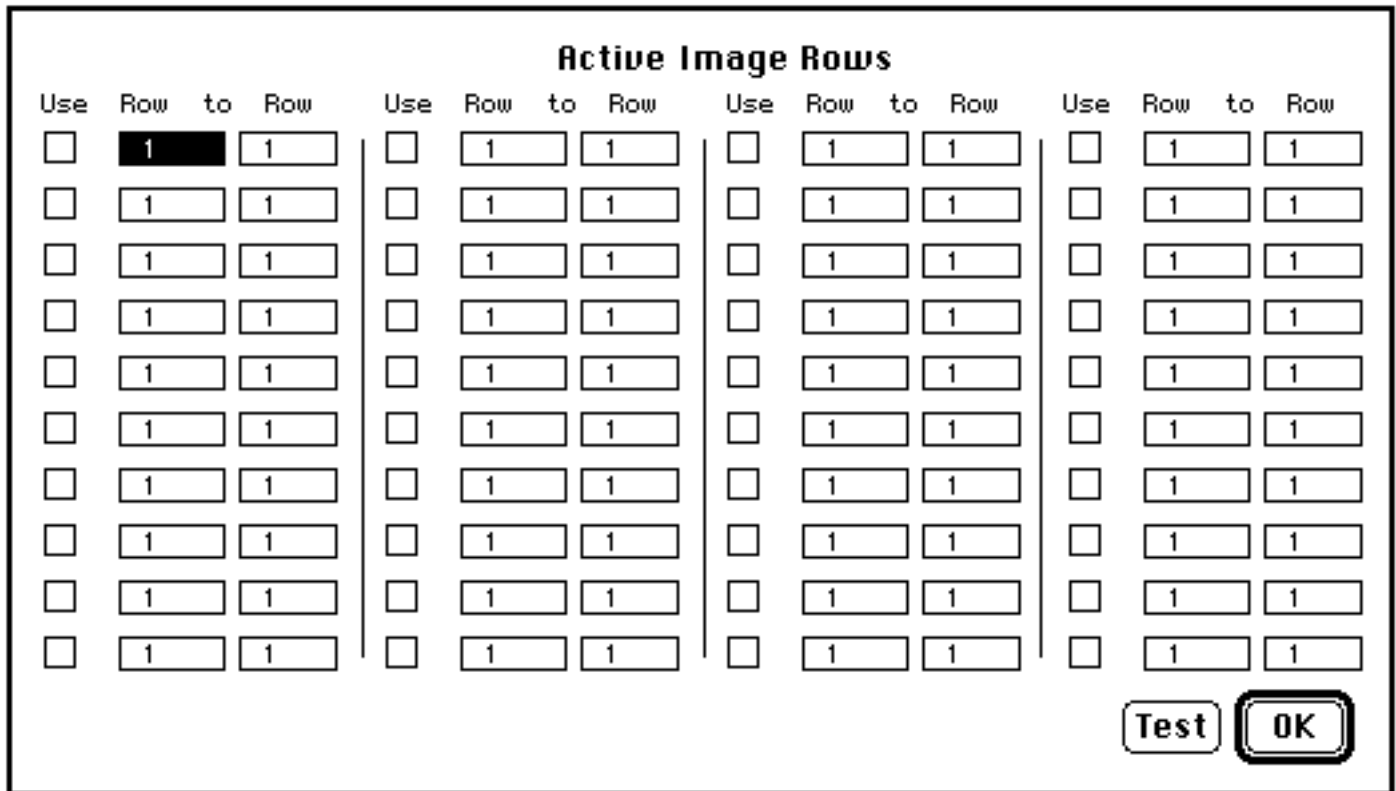
- Turn off the **All** button in the Binning Setup window to enable multiple-subarray readout of the CCD.



- Click the **Active Rows...** button:



The **Active Image Rows** window will open:



- In the **"Row to Row"** fields, type the first and last rows on the CCD that you want to include in the first image subarray (stripe).
- Click the **Use** button for that set of rows to activate the subarray.
- Repeat the above two steps for each of the remaining image subarrays.
- When you are finished, you can check the validity of the subarray definitions by clicking the **Test** button. This scans the row numbers make sure they are multiples of the current row group size. It also verifies that subarray stripes do not overlap.
- Click the **OK** button to return to the Binning setup window. The green rectangle and the other binning settings will show the entire area covered by the subarrays.



- Enable the **All** button only if you want only one image subarray.

Spectrum Curves are Automatically Associated with Multiple Image Subarrays

If you have selected multiple image subarray stripes, you will see an alert message when you close the Binning Setup window:



**Auto update 'Image->Curve{s}'
'Custom' curve bands to
match active image segments?**

Click **OK** in this alert window, unless you want spectrum curves that don't correspond to the image subarrays ("segments"). In the latter case, you can use the *Setup:Image->Curves* menu to select the desired custom curve-band definitions.

Camera Configuration

- Select the *Setup:Camera Configuration* menu to read or change settings that affect the camera operation:

Camera Configuration			
Serial Dimension	<input type="text" value="750"/>	Video Offset (0-255)	<input type="text" value="176"/>
Parallel Dimension	<input type="text" value="242"/>	Com Port Timeout (s)	<input type="text" value=".25"/>
ST-6 ROM Version	<input type="text" value="03.07"/>	Temperature	<input type="text" value="-30.0"/>
Antibloom % (1-100)	<input type="text" value="1"/>	Current Video Output: 4011	
No. of Cleans	<input type="text" value="0"/>	Actual CCD Temperature: -29.9° C	
<input checked="" type="checkbox"/> Data Compression		Actual Cooler Setting: -30.0° C	
<input checked="" type="checkbox"/> Control Temperature		Cooler-Capacity Usage: 100 %	
<input checked="" type="checkbox"/> Anti-Blooming On		<input checked="" type="checkbox"/> Double-Correlated Sampling	
<input type="checkbox"/> Use Shutter		Serial Baud:	<input type="text" value="19200"/> ▼
<input type="checkbox"/> Use Trigger In	<input type="checkbox"/> Use Trigger Out		
<input type="checkbox"/> Trigger Only 1st Accum		<input type="button" value="Cancel"/>	<input type="button" value="OK"/>
<input type="checkbox"/> Trigger Only 1st Scan			



- The **Serial** and **Parallel Dimension** show the CCD chip size and can't be changed.
- The **ST-6 ROM Version*** should be 3.07*to enable all binning modes and triggering capability. (Newer ROMs may be available.)
- **Antibloom %** sets the level of antiblooming control voltage applied to the CCD. Usually the best setting is the minimum (1).
- **No. of Cleans** sets the number of times the CCD is read out immediately before each exposure is made. Normally set at zero.
- **Serial Baud:** sets the data rate from Mac to CCD. Maximum data rate is 57600. Maximum usable data rate depends on Mac CPU. If data rate is set too high the system may "freeze up" during image readout to Mac.
- **Use Trigger In, Out** - select if you need triggered data acquisition. See the Appendix on this topic for details.

* As of December 1994.

Camera Configuration

- **Video Offset** sets the bias voltage applied to the CCD sensor output in order to bring the dark signal level within the minimum detectable range of the analog-to-digital converter in the ST-6l. This value is automatically set the first time the software talks to the ST-6l camera, unless the offset value was read in from the preferences ("PREFS") file.

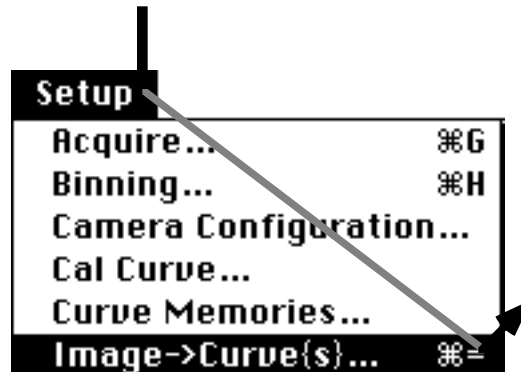


The video offset must be high enough so that the dark video signal (displayed in the Camera Configuration window) is at least a few hundred to a few thousand counts. The required video offset value will change as the CCD temperature changes. If the ST-6l readout is null data (all zeros) or saturated (constant, high value) you need to increase or decrease the video offset value, respectively.

- **Com Port Timeout** is the time interval the software will wait for a response from the ST-6l camera after sending a command. (You should normally not change this setting.)
- **Temperature** is the desired temperature setting for the CCD sensor.
- **Data Compression** approximately doubles the speed of the image readout from the ST-6l to the Macintosh, with no loss of data precision. Leave this button turned on.
- **Use Shutter** causes the camera to close its shutter blade while it is digitizing the image from the CCD. Normally this button can be left turned off (thereby saving wear on the shutter). The ST-6l uses a frame-transfer type CCD that does not need shuttering unless the light irradiance is high enough to cause "blooming" into the masked area of the CCD during chip readout.
- **Control Temperature** enables the thermoelectric cooler.
- **Anti-Blooming On** enables antiblooming. This should normally be on, with the minimum antiblooming value (1%) set.
- **DC Restore Readout** enables DC restoration of the signal.
- **Double-Correlated Sampling** achieves lower-noise readout at the expense of slower digitization speed. Setup and system focus run slightly faster with this turned off.

Image->Curve{s}: Formatting Spectrum Curves from Images

Select the *Setup:Image->Curve{s}* menu to specify how spectrum curves will be made from the current image-binning setup.



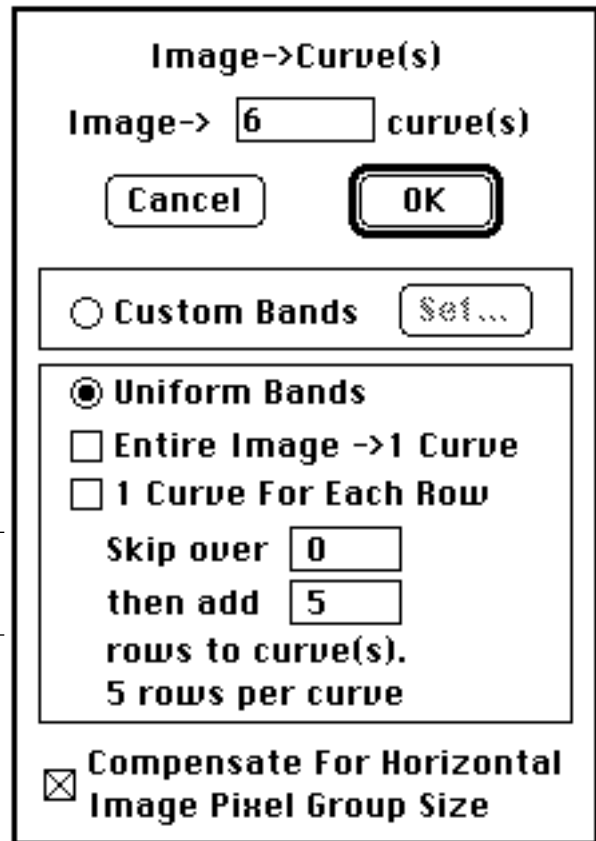
This field shows the number of curves that will be made from the image.

"Radio" buttons select "Custom" (arbitrary) or uniformly spaced curve bands.

Shows how image rows are summed into uniform curve bands.

Regardless of image pixel group size, spectrum curves always have the same number of active-data

pixels when this button is on. A nonlinear resampling algorithm that minimizes aliasing effects is applied to the image pixels to interpolate the required number of pixels for spectrum curves to achieve an effective image pixel group size of 1. Thus, each spectrum-curve pixel corresponds to one horizontally-ungrouped image pixel. (This eliminates the need for re-calibration when the horizontal image pixel group size is changed in the Binning Setup window.)



Custom curve-band selection

- Click the "Custom" radio button and the "Set" button to select arbitrary stripes of an existing image for spectrum curves.

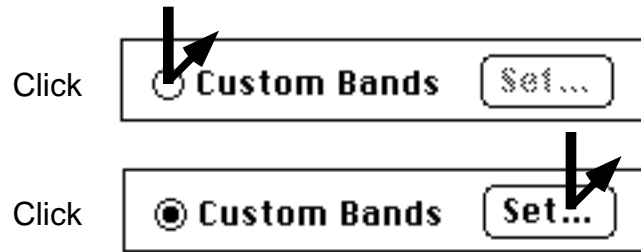


Image->Curve Bands

Use	Y1	to	Y2	Use	Y1	to	Y2	Use	Y1	to	Y2	Use	Y1	to	Y2
<input checked="" type="checkbox"/>	20		35	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input checked="" type="checkbox"/>	57		78	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input checked="" type="checkbox"/>	95		118	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1
<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1	<input type="checkbox"/>	1		1

- Type the *actual* image row numbers (i.e., the rows of the image after binning) into the Y1 to Y2 fields for each curve band. A "band" is the range of row numbers Y1 to Y2 that is used by the curve.
- Select the **Use** button to activate the curve band.
- Repeat the above two steps for each desired curve band. You can format up to 40 different custom curve bands. Bands may be formed from overlapping areas of the image.
- ➡ • You must verify that no curve band is assigned a larger row (Y) value than the the actual number of rows in the image.
- The **Save** and **Open** buttons let you save and recall custom curve band formats.

Spectral Calibration

The *Calibration Setup* window appears when you select the *Setup: X-Axis Calibration* menu. It has 15 pairs of edit fields for entering pixel numbers and corresponding known wavelengths. A pop-up menu at the lower left allows choosing the type of curve fit to be used to generate a calibration curve "CAL curve" using the known-wavelength pixels.

CAL Curve

The CAL curve (curve memory 0) is computed when the "Update CAL Curve" button is clicked. Only the pixels with the "Select" button on (i.e., marked with an 'x') will be used in computing the CAL curve. You can plot curve 0 to view the contents of the CAL curve; its plot displays <calibrated unit> versus pixel number.

1-Point Cal

The "Use 1-Point Cal if Valid" ignores the CAL curve in favor of valid KestrelCal 1-Point Cal information associated with a spectral curve. Each curve has its own 1-Point Cal information (viewable in the Curve Info window) which is valid if the "Known Pixel" value is greater than zero. (See the next section for more details.)

Saving CAL Curves

CAL curves can be saved to disk and opened later using the corresponding buttons in the Calibration Setup window. The wavelength points used to create the CAL curve are automatically saved.

Example

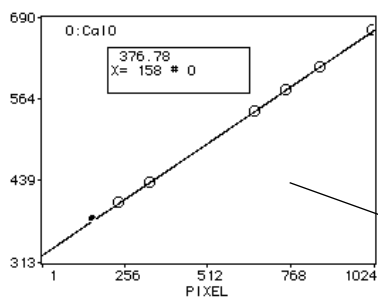
Make sure *Points Per Curve* is set to at least 1024 (use the *Setup: Curve Memories* menu). Select the *Setup: X-Axis Calibration* menu and enter the values and button selections as shown in the figure below.

Select:	Pixel	Value
<input checked="" type="checkbox"/>	241	404.66
<input checked="" type="checkbox"/>	334	435.83
<input checked="" type="checkbox"/>	660	546.07
<input checked="" type="checkbox"/>	757	579.07
<input checked="" type="checkbox"/>	861	614.306
<input checked="" type="checkbox"/>	1024	669.327
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		
<input type="checkbox"/>		

Laser Line (nm)

Use 1-Point Cal if Valid

Fit



Next press the "Update CAL Curve" button. When the update is finished, exit the Calibration Setup window by clicking OK. To view plots calibrated with the CAL curve, select the *Style:Calibrate X Axis:Wavelength {nm}* menu. The X axis of every curve plot will be displayed in nm according to the CAL curve you created.

To view the CAL curve, plot memory 0. (Press the "XY" button if you need to autoscale.) The calibration points are marked by circles on the CAL curve plot.

Raman-shift calibration requires labeling the X axis with the cm-1 frequency-shift values, where the shift is from the frequency corresponding to the excitation (laser) wavelength. The cm-1 values are automatically computed and displayed when the *Style:Calibrate X Axis:Raman Shift {cm-1}* menu is selected.

You can also calibrate Raman spectra by directly entering known cm-1 shift values and corresponding pixel numbers in the Calibration Setup window, then selecting the *Style:Calibrate X Axis:Wavelength {nm}* menu. For such direct-Raman curve fits, the displayed X axis label can be manually edited (e.g., to "Raman Shift (cm-1)" by selecting the *Set:Axes* menu and typing the desired label into the X: edit field.

Excitation-Profile Studies

In certain cases (e.g., Raman excitation profile studies) you may have several spectral curves that were obtained using the same spectrograph setting (i.e., same emission wavelength range) but with different excitation wavelengths. There are two different ways to display overlay plots of excitation-profile studies. In either case, Select the *Style:Calibrate X Axis:Raman Shift {cm-1}* menu. Leave the "Laser Line (nm)" field in the Calibration Setup window blank and enter the correct "Excitation Wavelength" value in the Curve Info window for each spectrum. (To access the curve info window double-click on the title of the curve or select the *Display:Curve Info* menu.) Then do as follows:

(Method 1: *lock to wavelength*) Select the *Set:Axes* menu, turn on the "Show All 3D X" button; this will cause the X axis labels to be drawn for each curve in a 3D overlay plot. In this plotting mode, all curves points will be positioned according to wavelength, but calibrated according to Raman shift.

(Method 2: *lock to Raman shift*) Select the *Set:Axes* menu, turn on the "Linearize X" button. This will cause the positions of the plotted points from each spectral curve to correspond to their cm-1 shift values. A given Raman peak in a spectrum will then line up with the same peak in all other spectra, regardless of excitation wavelength.

1-Point Calibration

KestrelCal™ 1-point spectrum calibration

The "traditional" way to calibrate spectra is by using a calibration curve generated from a spline fit to known spectral points. Several spectral reference points are required because of the inherent nonlinearity of grating spectral dispersion. While accurate, this technique has the disadvantage that new spectral points must be located (and a new calibration curve generated) every time the spectrograph wavelength is changed.

KestrelCal 1-Point calibration takes a different approach. If the wavelength for one sensor pixel wavelength is known, one can accurately determine the wavelengths that correspond to all other sensor pixels. Certain parameters concerning the spectrograph and sensor characteristics are also required, which do not change when the spectrograph wavelength is changed. These parameters are setup using the *Setup:: X Axis Calibration* menu, then clicking the "Setup 1-Point Cal..." button in the Calibration Setup window.

Setup 1-Point Cal...

Spectrograph Info:	Update Curve	<input type="text"/>	through	<input type="text"/>	
Known Wavelength =	<input type="text" value="500"/>	nm at Pixel	<input type="text" value="0"/>		
Spectrograph Angle =	<input type="text" value="12.000001"/>	Degrees			These values don't change unless you change the grating or move the detector.
Spec. Focal Length =	<input type="text" value="500"/>	mm			
Grating Grv. Density =	<input type="text" value="1200"/>	g/mm			
Detector Pixel Size =	<input type="text" value="23"/>	microns			
Excitation Wavelen. =	<input type="text" value="457.9"/>	nm			
			<input type="button" value="Cancel"/>	<input type="button" value="OK"/>	

- Set **Pixel** to the spectrum curve pixel corresponding to the **Known Wavelength**. (Setting it to 0 disables KestrelCal.)
- **Spectrograph Angle** is the *total included angle* of your spectrograph. Contact the spectrograph manufacturer if you don't know this value.
- **Spec. Focal Length** may vary slightly from the nominal value, depending on the actual detector position.
- **Excitation Wavelen.** is the same as the "Laser Line (nm)" value shown in the Calibration Setup window.

KestrelCal

Once the spectrograph information is setup, all newly-acquired curves will have the KestrelCal spectrograph info automatically attached to them. (The spectrograph info. associated with a particular curve is visible when the curve info. window is displayed.)



KestrelCal spectrograph information will be used in preference to the cal curve (memory zero) for X axis calibration, unless "Use 1-Point Cal if Valid" is turned off in the Calibration Setup window.



To disable KestrelCal for a particular curve, select the *Display: Curve Info* menu and set the "Known Wavelength Pixel" to 0.

Dark-Background Subtraction

Usually you will want to subtract dark (background) data during data acquisition. There are two different background-subtraction methods:

- **Use Set Background** - a dark image or curve ("background blank") pre-stored in the Macintosh is subtracted after the data is transferred. You must first set a curve or image as the background blank using the *Set : Set as Background Blank* menu.



(A curve can be used as the background if only one spectrum curve is made from the image; otherwise the background must be an image.)

There are special curve- and image- memories for the background blank. The background curve memory number is <maximum data curve number + 2>, e.g., memory 52 for the default setting of 50 data curve memories.

- **Dynamic** background subtraction - a dark image is acquired immediately before each exposure. It is then subtracted immediately after the exposure. This is the appropriate method if the CCD temperature has not stabilized.

Chapter 3:

Reference

Importing Data

Import Raw Data

File Header Length
0
(Bytes)

Cancel OK

Pixels/Row 384

Bytes/Pixel 1 2 4

Max Row No. AUTO

Ex Bytes/Row 0

Invert Byte Order

Signed Integer

Import data as:

Integers

Floating-point values

File has:

One or more columns

One column

Start new curve(s)
after every text header

Cancel OK

Raw Data to Image... loads a binary integer image file (in uncompressed row-by-row format) into the active image. A dialog window automatically appears where the file header length, pixel-byte size (1,2 or 4 bytes per pixel), row length and number of rows are entered.

If you don't want to open all of the image, set *Max Row No.* to the number of image rows to load.

Ex Bytes/Row is the number of extra (non-image) bytes at the end of each image row. (Usually this is zero.)

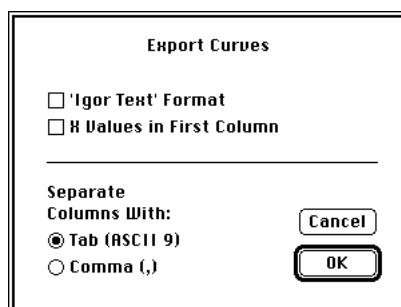
Turn on *Invert Byte Order* to load 2-byte and 4-byte per pixel image data created on IBM-type PCs. Turn on *Signed Integer* if the file contains signed, 2-byte integer data.

PICT File to Image... converts any PICT file to a 256-gray level image and copies it to a 16 bit/pixel active image. (For best results, the PICT should be a grayscale image with at least 256 grays.)

Text File to Curve{s}... loads a text (ASCII) file into available curve memory(s). The file can be in tab- or comma-delimited column format, or may be a single column. Any file rows (e.g., header) that contain non-numerical information are automatically skipped. An option allows automatically starting a new curve after every text header.

Text File to CAL Curve... loads a text file into curve memory 0, which causes it to be used as a calibration curve.

Exporting Data



The following items are accessed via the *File:Export* menu:

Export Curves{s} as Text... Saves the curve(s) currently shown in the display window in tab- or comma-delimited, column format. (This format can be opened by most spreadsheet- and analysis-software.)

The first column can be set to contain the X-axis values, which will correspond to the currently displayed X axis calibration style. Only the displayed X range is saved. If overlay mode is in use, it will save the curves in the order in which they appear in the overlay, starting with the rearmost curve in the plot.

Igor™ users can export files in *Igor Text* format.

Export Image as Raw Data... saves the image as a simple binary, row-by-row data block without header or other information.

Export Image as PICT File... saves the image as a color 8-bit/pixel PICT file.

Auto-Saving Data to Disk

The *File:AutoSave* menu lets you select the location on disk for automatically saving curves and/or images. When you make this menu selection, a file dialog window will open. Use it to select the disk folder where you want the data to be stored, then click OK. Making this selection enables AutoSave mode and tells the system where to automatically save data. Data will be automatically saved to disk as it is received from the detector system.

AutoSave Curves as Text uses the format specified in the Export Curve{s} as text dialog window. (The other autosave options save data in the proprietary, binary format standard to this software.)



Once enabled, autosave remains in effect until this menu is again selected and the "Cancel" button is pressed in the file dialog window.

PREFS File

The ***File:Update PREFS File*** menu saves a special file that will be automatically opened every time KestrelSpec starts up. It contains information about various settings and graphics parameters. The PREFS file must be left in the same folder as the KestrelSpec.

Printing

The following items are accessed under the *File* menu:

Set Print Margins... opens a window with edit fields for setting the printed page margins as percents of the total page width and length. Turn on "Use Highest Resolution" and set the printing magnification in the 'Page Setup' window to a small value (e.g., 25%) to use the best possible printing resolution.

Page Setup... opens the standard Macintosh Page Setup window.



For best results in most cases configure the Page Setup as follows: *Orientation*: "wide" or "landscape" format. *Graphics Smoothing*: turned off. *Font Substitution*: turned off.

Reduce or Enlarge: set at 100% for normal plot resolution. When the "Use Highest Resolution" button is selected in the "Print Margins" window, setting this value to 50% or 25% effectively doubles or quadruples the numbers of pixels in the printed output, instead of reducing the size of the plot. (The resolution of plots copied to the clipboard is affected in a similar manner.)

Print... prints whatever is shown in the display window. The output (plots, images) will be in full color when a color printer (e.g., DeskWriter C) is used. High quality grayscale images can be obtained from a printer with good grayscale capability, such as Apple LaserWriters with PhotoGrade® or other laser printers with 600 dpi or better resolution.

Print All Curves... puts all curve memories on the keypad stack so that each will be printed, one curve per page.

Paste Curve

The *Edit:Paste Curve...* menu opens a window where you enter the range of pixels from the curve to be pasted, and the start pixel for the curve to be pasted into. Any part of a curve can be pasted at any location into any curve, including itself. This allows curves to be manually joined together, or shifted along the X axis.

Auto-Join Curves

Edit:Auto-Join Curves automates the pasting together of curves that have valid KestrelCalspectrograph info data. (The spectrograph info data for a particular curve is accessed in the curve information window.) The Auto-Join process finds the pixel location in two curves where the wavelength matches, and joins the curves together at that point.

Enter the range of curve numbers you wish to join in the dialog window.

The total curve length (number of "pixels" or "points") must be long enough to accommodate the joined curves. Increase the curve length, if necessary, by selecting the *Setup: Curve Memories* menu.

Turn on **Replace Original Curves** if you do not want to keep the original, separate curves.

The **First Active Pixel** and **Last Active Pixel** values should be set to correspond to the range of pixels for which any curve could have nonzero pixels. Auto-Join will ignore pixels not in this range.

General Settings

The **Set:General Settings...** menu opens the *Settings* window:

- **Use Grid Lines**- add dashed lines perpendicular to the X and Y plot axes.
- **Curve Info on Print** - adds the curve info for the active curve at the bottom of the printed page (or clipboard).
- **AutoColor Overlays** - colors the line for every 5th curve red instead of black. It does not affect the paint fill color.
- **Sound Effects** - adds sound to certain actions, such as the Z scroll button and editing in the catalog.
- **Disable Warnings** - turns off most alert and status messages which warn the user about loss of data, etc. Also removes the "grow icon" from the image display window.
- **Transform is New Curve** - a new curve memory is used for the result of a smooth or other curve process. If this is not selected, the original curve will be replaced.
- **Round Off Y Labels** - round numbers on Y axis of plots to 3 significant digits.
- **Off-Screen Drawing** - use memory-buffered plotting.
- **Flash Active Curve** - active curve in overlay is continuously flashed.
- **Auto <Y> Scale** - autoscales min,max Y values.
- **AutoShow New Data** - updates display for each new curve or image.
- **Auto Image Brightness** - sets the brightness automatically.
- **Clear Curve Before Scan** - erase curves before acquiring new data.
- **Auto Spike Filter** - new images are filtered for spikes. Use only when you know that the smooth/peak threshold control is properly adjusted.
- **Get Log of New Curves** - takes log base 10 of curve during scans. (Requires Macintosh with FPU math coprocessor.)
- **Always Show Cursor** - the X,Y position cursor is always shown.
- **Copy Plots as Object Drawings to Clipboard** - creates an object-oriented PICT drawing which has each element (axis, etc.) as a separate object.

Axes Settings

Set:Axes... opens a window where the scales and format of the plot axes are set. (A double-click on plot axis will also open this window.)

Set X Cursor Range causes the range for the XY cursor scroll button to be limited to the current X Min and X Max values.

Show All 3D X - each curve in 3D plot will have X axis labels drawn.

Linearize X makes plotted pixel positions correspond to their calibrated wavelength- or Raman shift- values. When Linearize X is enabled, X Min and X Max are specified directly in the current X-axis display units (pixels, nm, or cm-1 shift). It forces the X Min and X Max to "lock in" onto values specified in nm or cm-1.

The **X-axis label** should be left as <AUTO> except to override the default settings of "PIXEL," "WAVELENGTH nm," and "RAMAN SHIFT cm-1." Y- and Z- (channel profile) labels are used as entered.

Thresholds

Set:Thresholds... sets values used for **smooth**, **spike-filter** (and **flat-field notch-filter region**, when flat-field blank is a curve) processes and for finding **peaks** in curves. The correct settings will depend on the background noise level in the data. Set peak and spike thresholds to 0 to find every curve peak or filter every image spike. Adjust smoothing threshold to a large value to smooth all points in a curve. The flat-field notch settings cause values in the notch region of a flat-field curve to be set to a very large value, effectively zeroing the pixel values of flat-fielded curves in that region.

Threshold Settings	
Peak Finder	<input type="text" value="20"/>
Curve smoothing	<input type="text" value="100"/>
Image spike filter	<input type="text" value="500"/>
Flat-field curve notch filter (%)	<input type="text" value=".5"/>
Flat-field curve min value (%)	<input type="text" value=".05"/>
Flat-field curve notch (left pixel)	<input type="text" value="1"/>
Flat-field curve notch (right pixel)	<input type="text" value="1"/>

Suppress flat-field notch region by:

% Threshold

Left, right pixel

Peak Finder Settings

The **Set:Peak Finder** menu is used to set

- the number of peaks that will be automatically located on the first click
- whether the **peak width** (used for peak-area calculation) is determined **automatically** (± 1.5 FWHM) or **manually**.
- the **Baseline Correct** setting causes the peak finder to compute baseline-corrected peak areas
- **Save Peak Info** causes data for peaks to be automatically saved to disk (during live scanning or when the peak finder is quit). The saved data includes peak pixel, wavelength or cm-1 value (if using a calibrated axis), height, full width half max (FWHM) and area. The data is saved in tab-delimited ASCII text format with a single header row of column titles.
- **Get Centroid** causes the peak pixel location to be determined from the centroid (5-pixel weighted average) location. This method of peak location can yield more precise results. It is recommended that this setting be enabled when locating peaks for generating a calibration curve.

Auto Background Subtraction

The *Set:Auto Background Subtraction* menu enables the automatic subtraction of a dark background reference (image or curve) from newly acquired data:

Use Set Background Curve: A curve that has been set as the background will be subtracted from each new curve input from the camera. (For curve background subtraction, the setup must yield 1 curve from the entire image.)

Use Set Background Image: If an image has been **set** as the background blank (using the *Set* menu), it will be subtracted from each new image input from the camera.

Dynamic Background Image: A new, dark background image will be automatically acquired (i.e., an exposure with the camera shutter disabled) and subtracted after *every* exposure.

Auto Transform to Absorbance

Auto Transform to Absorbance - new data is automatically converted to absorbance (optical density) values. The absorbance blank memory (Maximum Curve No.)+3 must be previously set. This function only works when 1 curve band is selected in the "Image ->Curve{s} " window:

Auto Flat-Field Correct

Auto Flat-Field Correct - new data is automatically normalized for variations in pixel response by (i) dividing by the flat-field blank and (ii) multiplying by the average of the flat-field blank. The flat-field blank image or curve (Maximum Curve No.)+4 must have been previously **set** with the *Set* menu.

Set as Background Blank

Set as Background Blank - copies the active *curve* or *image* to the background reference memory. *If an image or background image is displayed*, the background image buffer is updated and set as the permanent (static) background; otherwise the active curve is copied to memory (maximum curve no. + 2) and set as the permanent background. **To undo** the set command, clear the background image or curve memory (max. curve +2) with the *Edit:Clear* menu.

Set as Absorbance Blank

Set as Absorbance Blank - copies the active curve to the absorbance blank reference memory (max. curve +3). Can only be used when data from the image is transferred to a single curve memory, i.e., when 1 curve band is selected in the *Image->Curve(s)* Window.

Set as Flat-Field Blank

Set as Flat-Field Blank - *:This Data* copies the active curve (max. curve +4) or image to the flat-field blank. *:File* opens a curve or image from disk and sets it as the flat-field blank. The flat field should be obtained by exposure with uniform, white light. The "noise" created a wavelength-notch filter with a flat-field curve can be suppressed by settings in the *Set:Thresholds...* menu.

Style Menu

- **Plot** selects the way the outline of a spectrum graph is drawn.
- **Line** selects a color (red, green, blue, yellow, cyan, magenta, black) for the plot line.
- **Fill** selects the color that is used to fill the inside of the plot of a curve. (The exact meaning of "inside" depends on the plot style.) Choosing *Color ...* opens the color selector window on Macs that have color QuickDraw. The number of different custom fill colors is determined by the number of colors displayable on your monitor, e.g. 256 colors for 8-bit monitors.

In **overlay plots**, the selected plot style, line- and paint- color are automatically applied to new curves added to the overlay.



To change the active-curve style in an overlay plot, select the desired characteristics with the *Style* menu, then choose the *Edit:Overlay:New Style on Active Curve* menu.

- **Image** allows selecting between positive grayscale, negative grayscale, and 23-level pseudocolor image display palettes. It also has the following items:

Show Intensity Scale - adds a legend at the right edge of the image display for the relation between color (or gray level) and intensity. Using the legend, a color of a pixel in the image can be associated with an intensity range. (For negative darkness settings less than -3 not all legend colors are actually used in the image.)

Show Negative Pixels - all pixel values will display according to their absolute value. When turned off, negative pixels are displayed as zero value.

Dither Image Display - Simulates additional colors on devices with fewer than 256 colors or grays. (Image-display updates are significantly slower.)

Image Fits Window - the image is stretched to fit the display window.

X, Y Profile Plot - add graphs of the the intensity for the center column and/or row of the image. The profile lines can be dragged with the mouse, or moved with the arrow keys on the keyboard. (Hold down the *option* key to make the arrow key move the profile line 10 pixels at a time.)

Process Menu

Smooth reduces low-level noise fluctuations in the active curve while preserving "real" peaks. (Use the *Set:Thresholds* menu to adjust the effectiveness of this process.)

Flatten Baseline finds peaks and subtracts the local baseline intensity value from each one. (Use the *Set:Thresholds* menu to adjust the effectiveness of this process.)

Convert to Int/Float- selecting this changes the active curve from integer to floating point (or *vice versa*). Integer-format curves plot faster than floating-point curves. Floating-point curves have greater dynamic range, as well as better precision at small count values. (An exception is the Cal curve, memory 0, which must always be in floating-point format.)

Derivative dy/dx computes the first derivative (slope) of the active curve, on a pixel-by-pixel basis.

Create Baseline... - lets you fit an n th order polynomial to selected points for baseline subtraction. See detailed description on next page.

Curve math... opens a dialog window that enables arithmetic operations (+, -, /, X) on one or more than one curve at a time. Use it, for example, to subtract the same curve or constant value from a range of curve memories.

Stretch Curve {Resample} changes the number of pixels in curves. The process uses a nonlinear interpolation kernel that minimizes aliasing effects while optimizing retention of genuine data characteristics.

Renormalize Curve X Axis takes the active-curve pixels and maps them onto uniformly spaced pixels of arbitrary wavelength interval. The active curve must have valid calibration information (Cal curve or KestrelCal spectrograph info). See the detailed discussion of this process on the next page for more information.

Copy Image to Curve{s} - copies the active image to curve memories, using the format specified by the *Setup: Image->Curve{s}* menu.

Remove Image Spikes - applies the spike filter to the active image. (Use the *Set:Smooth, Peak Threshold* menu to adjust the effectiveness of this process.)

Subtract Background Image - subtracts the background image from the active image.

Flat-Field Correct Image - first multiplies the active-image pixels by the average of the flat-field pixel values, then divides the active image by the flat-field image.

Flip Image Horizontal - active image is transformed to its "mirror image".

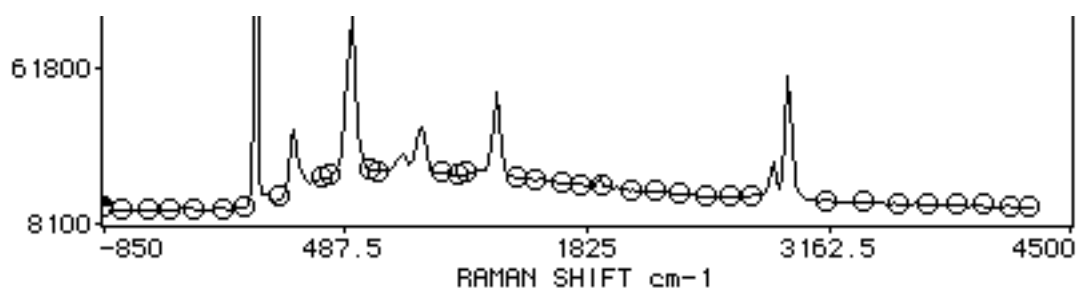
Flip Image Vertical - active image is inverted top-to-bottom.

Image->{+,-} Integers; Image->{+} Integers - switch the displayed image between signed and unsigned integer type.

Create Baseline...

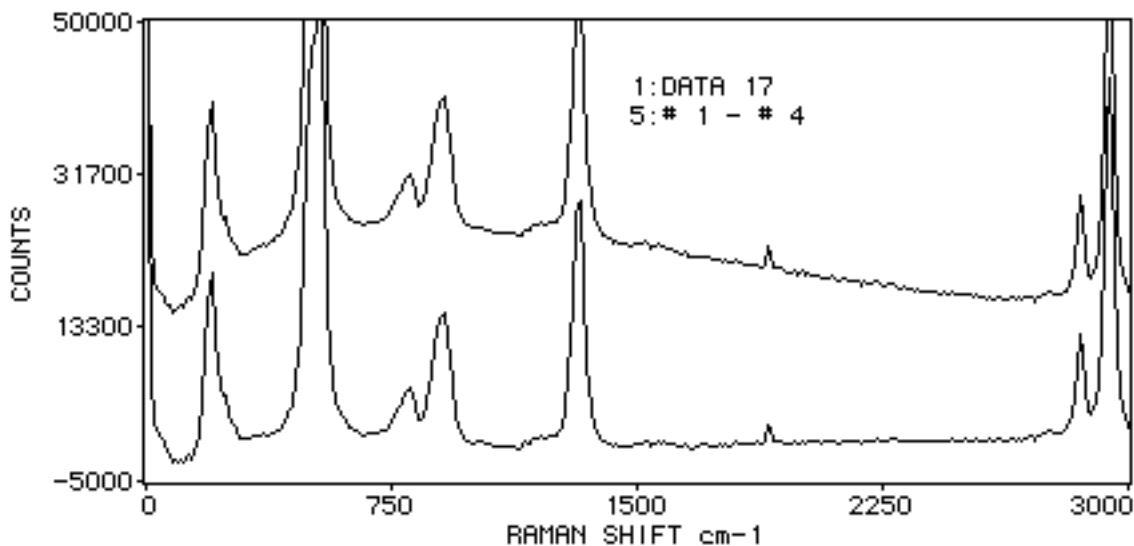
Spectra often contain narrow peaks which are offset along the intensity axis by varying amounts due to a relatively broad background, or "baseline." One can generate a "baseline" spectrum which represents the original spectrum minus the narrow peaks. The baseline spectrum can then be subtracted from the original spectrum to effectively flatten its baseline.

The *Process:Curve>Create Baseline...* menu lets you select up to 99 baseline points in the active curve by clicking on them in the curve-plot display. Each selected point is outlined by a circle as shown in the figure below. Use the *Edit:Undo* menu to unselect the last-selected point. Clicking on any selected point will unselect it.



When you are finished selecting baseline points click the *OK* button on the Control Palette, or press *return* on the keyboard. The selected points are fit to a polynomial of user-specified order 1 through 10, and the new (baseline) curve is placed in the next-available curve memory. The baseline curve is computed for the range of displayed points. The new curve will have the numerical format (integer or floating point) of the original curve.

As shown in the overlay plot below, you can subtract the computed baseline curve from the original spectrum to flatten the baseline, while preserving all fine structure in the spectrum.



Renormalize Curve X Axis

The wavelength (or Raman cm^{-1} shift) resolution of an array detector depends on pixel size, spectrograph focal length, grating density and other factors. The wavelength (or Raman cm^{-1}) range covered by a pixel also varies depending on its position in the array.

However, one often needs to display spectral data with the curve-pixel resolution in some standard, uniform unit such as 1.0 nm per pixel. The **Renormalize Curve X Axis** process enables you to transform any calibrated spectrum curve into a new curve with uniform pixel resolution that you specify.

Unlike many other types of interpolation process, Renormalize X Axis is well-suited for transforming spectral data because it preserves the total area of the spectrum and it does not distort line spectra. To use it, do the following:

- Plot the curve you want to renormalize. (In an overlay plot use the Z scroll button to make it the active curve.)
- Select the *Process:Renormalize Curve X Axis* menu. For KestrelCal-calibrated spectra the watch cursor will spin for a few moments while temporary calibration data are computed.
- Type the lower- and upper- wavelength limits you want the new spectrum to cover in the **From Wavelength** and **To Wavelength** fields. (If the plot display is in Raman mode, these limits will be in cm^{-1} Raman shift instead of nm.) Zeros will be used for the intensity (count) values whenever the requested wavelength (or Raman cm^{-1}) range extends outside the range of the active curve.
- Type the desired pixel resolution for the new curve in the **Interval Between Points** field. Spectral resolution will be reduced when the new curve has lower resolution than the original spectrum. If the interval corresponds to a much smaller pixel interval than the original curve, you may get better results if you first stretch the curve before renormalizing it. (The stretch process minimizes aliasing effects associated with generating a smaller interval.)
- Click *OK* to generate the renormalized curve. The new curve will have appropriate KestrelCal information automatically attached to it. The new KestrelCal parameters represent the slope and intercept of a straight line, since the renormalized curve has, by definition, perfectly linear wavelength (or Raman cm^{-1}) dispersion.

Integrals

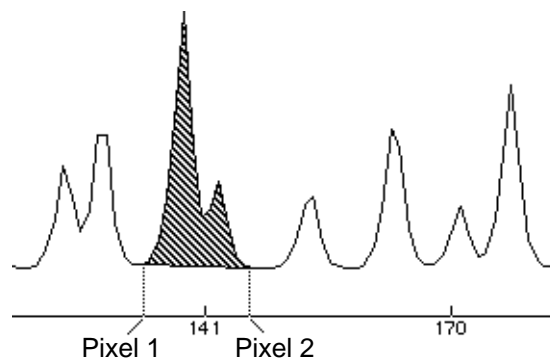
The area of peaks ("regions") can be calculated using the *Process:Integrals* menu. You can also create Y(t) [peak area versus curve number] spectrum curves from each of the defined regions.

Peak areas ("integrals") are calculated in one of two ways:

(1) The sum of all of the intensity values between (and including) a lower bound ("Pixel 1") and an upper bound ("Pixel 2") is given when the Baseline Correct button is *not* selected.

(2) When **Baseline Correct** is selected, a baseline function is calculated. This corresponds to a line drawn from the intensity value at Pixel 1 to the intensity value at Pixel 2. The integral is the sum of the difference between the the intensity values and the baseline (see figure below).

The baseline-corrected integral between Pixel 1 and Pixel 2 is represented by the shaded area.



• Computing Peak Areas

Enter the *Pixel 1* and *Pixel 2* numbers for each integration region. Click the **Calc** button to calculate the integrals. Type a different number in the **Memory->** field or press the "**<-**" or "**->**" button to change the memory for which the integrals are calculated. Pressing **Clear** erases all fields. (The regions are automatically saved and reloaded with the **Cal curve** file.)

Using the Mouse to Select Peaks

You can select the Pixel 1 and Pixel 2 values using the XY position cursor and the **Int** button in the control palette, rather than type these values directly into the edit fields. Position the cursor at the left side of the region, then click **Int**. A marker (I) will appear above that point, and a message will show in the upper left corner of the display to identify the pixel and region number. Move the cursor to the right side of the region and press **Int** again.

Make Y(t) Curves

When there is more than one curve in memory, the **Make Y(t) Curves** button is active. It creates, for each integration region, a new curve that shows the integral value ("Y") as a function of curve-memory number ("t"). If an overlay plot is currently displayed, only the curves in the overlay will be used to create the Y(t) curve(s). If there is no overlay plot, all curves in memory are used to generate the Y(t) curves.

Common Problems and Solutions

• **Problem:** The ST-6 system appears to be functioning normally but the data is blank (all zeros).

Solution: increase the video offset (use the *Setup:Camera Configuration* menu) until the the video reading is between a few hundred and a few thousand counts. Or choose the *Setup:Auto Set Video Offset* menu and KestrelSpec will find the set the correct value.

• **Problem:** The ST-6 system appears to be functioning normally but the data is the same for all pixels.

Solution: The data is saturated because (1) the light source is too strong, or (2) the video offset is too high. First check the video offset to verify that it is properly set. If this is not the problem, try reducing the light source or exposure time.

• **Problem:** The image display looks "posterized," and the intensity- scale colors don't seem correct.

Solution: Set the monitor control panel to at least 256 colors, if available.

• **Problem:** It takes a very long time (over 30 seconds) to acquire a spectrum or image, even though the exposure time is short.

Solution: The ST-6 is set for an a *imaging* (as opposed to *spectroscopic*) resolution mode, such as 375x242. Use the *Setup: Binning* menu to select a spectroscopic resolution mode such as 750x30. You must have either an ST-6I or ST-6V model to support spectroscopic binning modes.

• **Problem:** The Mac "freezes" when data is being read from the CCD, requiring a reset of the system.

Solution: The Mac CPU is being interrupted by a process other than the serial (modem) port, which conflicts with the interrupts required to read the CCD data. This problem is noticed on slower Macs, depending on system software configuration. Solutions, in the order that they should be tried, include: (1) Disable AppleTalk in the Chooser, (2) Disable Virtual Memory (use the Memory control panel), (3) turn on 32-bit addressing (also in the Memory control panel on some Macs), (4) remove non-essential system extensions (INITs) from the System:Extensions folder. If the above fixes are unsuccessful, select a slower RS232 baud rate (e.g., 9600 or 19200) with the pop-up menu in the window that appears when the Setup:Camera Configuration menu is selected.

Compatibility

KestrelSpec ST-6I and the Kestrel Macintosh ST-6I camera system can be used with any Macintosh having at least 2 MB RAM and System 6.0.5 or later. A Macintosh with at least 8-bit color or grayscale display and system 7.0 or later and at least 4 MB RAM are recommended. Recommended computers include the Macintosh LC, Classic II, Color Classic, Macintosh II series (all models), Centris, Quadra, and PowerBook series (except model 100), as well as Power Macintosh models.

The interface to the ST-6 camera uses the Macintosh modem port at up to 57600 baud (effective 114 kbaud rate with data compression). The KestrelSpec spectrograph control option uses the Macintosh printer port at 9600 baud, or (depending on spectrograph model) a National Instruments GPIB (IEEE-488) interface. PowerBook 200/500 series models require a docking station or other adaptor that separates the modem and printer ports if the spectrograph control option with RS-232 interface is used.

Spectrograph Control Option

KestrelSpec offers the ability to control the operation of certain spectrographs. (This is an optional feature that must be specified for your licensed copy of KestrelSpec.)

The KestrelSpec spectrograph control option consists of two parts:

(a) *the spectrograph control palette*, which is a "pull-down" extension to the normal Control Palette window, and

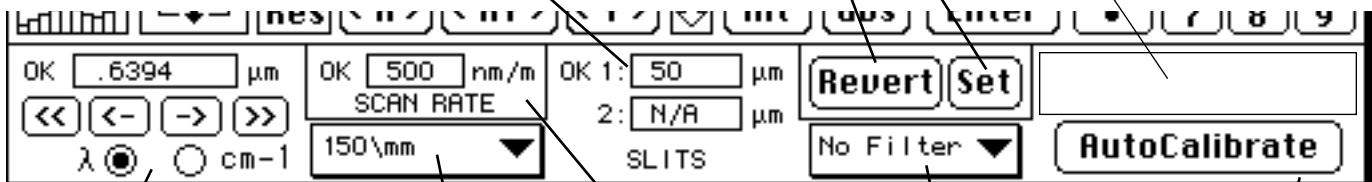
(b) *an extension to the Acquire setup window*, which allows automatic stepping of the spectrograph during a programmed sequence of scans.

(The figure below applies to CVI Laser DK240, Chromex Spectrograph Control 250,500 models. See next page for SMS LambdaScan version.)
Palette Extension

Slit controls. These fields set the entrance- and (if installed) exit- slit sizes.

Revert and Set buttons. Press "Revert" to undo any changes made in one of the edit fields. Press "Set" (or the "enter" key on the keyboard) to register changes in settings with the spectrograph. The "OK" symbol appears at the left of a field when the spectrograph actually has that setting. A "≠" symbol will appear instead for settings that have not yet been sent to the spectrograph.

Logo that identifies the brand and/or model of spectrograph controlled by your copy of KestrelSpec.



Spectrograph wavelength controls. Select the "cm-1" button to read out spectrograph setting directly in cm-1 Raman shift. The single-arrow keys (<->) make the spectrograph scan up or down in wavelength at slow speed. The double-arrow keys (<<, >>) make the spectrograph scan more rapidly. The "SCAN RATE" setting controls (depending on spectrograph model) either the slower(->) or faster(->>) scan speed.

Spectrograph scan-rate control. This edit field sets the speed at which the spectrograph will scan when the single-arrow (<- , ->) buttons are pressed.

Grating selection pop-up menu.

Select from up to 3 gratings. KestrelSpec automatically shows you the grating groove densities. Depending on spectrograph model, you may have to select the grating before its groove density is shown in the menu.

Filter selection pop-up menu. This menu allows for selection from up to six different filters installed in the optional input-filter accessory holder. The menu reads "no filter" if the accessory filter wheel is not installed.

AutoCalibrate button. Press this button to automatically calibrate your spectrograph-detector system against a known spectral line, or a white light source. See the next page for details.

**Spectrograph
Control
Palette
Extension,
SMS
LambdaScan
Version**

(Only features that differ from the description on the previous page are listed below.)

Step Delay: sets the delay between steps of the wavelength-scanning motor; range is 0-255. Maximum delay (255) corresponds to somewhat less than 1 s delay per step.

Spectrograph Type: set this pop-up menu to the SMS spectrograph you are using.

The screenshot shows the LambdaScan 937 control palette. It includes a wavelength display showing 449.981 nm, a grating selection dropdown set to 1200g/mm, a step delay input set to 1, a multiplier and offset input set to 32 and 3.20, and a spectrograph type dropdown set to Mono 27. There are also buttons for Revert, Set, and AutoCalibrate.

Grating Pop-Up Menu: set this to the grating that is actually in use in the spectrograph. (The actual grating selection is done manually.)

Multiplier and Offset: set the corresponding values used by the LambdaScan controller.

The *Multiplier* value is number of steps the wavelength-control motor must take to change the actual center wavelength of the spectrograph by 1.0 nm. The Multiplier value is determined automatically from the "Spectrograph Type" and "Grating" pop-up menu settings.

The *Offset* value is the "zero" reading (i.e., the setting automatically reset when the LambdaScan controller is turned on or the grating menu is changed) of the mechanical wavelength counter on the spectrograph, in raw units (i.e., not corrected for grating type). To set up the *Offset* value, wait until the spectrograph has reset after turning on the LambdaScan and pressing the "Enter" button on the LambdaScan controller. The value on the mechanical counter is the Offset. (KestrelSpec automatically corrects the raw counter value for the selected grating before updating the LambdaScan controller.)

The Multiplier and Offset values are "remembered" by the LambdaScan controller when it is turned off, so they do not have to be re-entered. Due to mechanical variations, the Offset value often has to be changed when a different grating is selected.

AutoCalibrate Procedure

AutoCalibrate

KestrelSpec (with the spectrograph control option) can automatically calibrate the wavelength (or cm-1 Raman shift) axis of your spectral curves. To use the AutoCalibrate feature, follow these steps:

- (1) Have a known spectral line located near the center ($\pm 20\%$) of the detector array. This line must be the highest peak in the field of view as the spectrograph is scanned over a small range. Enter the wavelength for this line in the wavelength-control edit field. Register the new wavelength setting with the spectrograph by pressing the "Set" button (or "enter" on the keyboard).
- (2) Click the "AutoCalibrate" button. KestrelSpec will obtain 3 data acquisitions while it automatically changes the spectrograph wavelength setting.
- (3) Wait for the scans to finish (this may take a few seconds). The wavelength axis will then be calibrated for all pixels, even when the wavelength setting of the spectrograph is changed.

How it Works

The AutoCalibrate method updates the spectrograph information parameters (accessed from the *Setup: X-Axis Calibration: 1-Point Cal* menu). These parameters include the spectrograph focal length, total included angle between spectrograph mirrors, detector pixel size, and center-focus pixel. The first three of these parameters are read directly from the spectrograph by KestrelSpec.

AutoCalibrate automatically finds the center focus pixel, and then uses the detector pixel size as the one adjustable parameter during the autocalibration scanning procedure. The computed pixel size determined may vary slightly from the actual pixel size, since the actual focal distance and grating groove density may be slightly different than the nominal values reported by the spectrograph.

This information is then used to extract, using the diffraction equation, the correct wavelength values that fall at any pixel on the detector array.

Raman cm-1 shift values at each pixel are directly computed from the individual pixel wavelength values and the laser excitation wavelength specified with the *Setup: Spectrograph* menu.

"White-Light" Calibration

It is possible to obtain approximate calibration with the AutoCalibrate procedure using "white" light (or any light source). Set the spectrograph to *zero* wavelength (0.0 nm) and adjust the light intensity so that the detector sees a narrow peak in the middle of the array. Press the "AutoCalibrate" button. The wavelength axis and spectrograph information parameters will be updated as described above.

Connecting the Spectrograph to your Macintosh

KestrelSpec with the spectrograph control option can control supported spectrographs via either an RS-232 or (certain spectrograph models only) GPIB interface connection.

- All supported spectrographs include an **RS-232 interface** as standard equipment. Connect the appropriate RS-232 cable between the printer port of the Macintosh and the RS-232 ("Host Computer") port on the spectrograph. Certain Mac models (e.g. PowerBook Duo, PowerBook 500 series) require a docking adaptor to supply the separate printer port. The spectrograph manufacturer can supply the required Macintosh interface cable.

GPIB Interface Option

- If your spectrograph is one whose **GPIB (IEEE-488) communication** is supported by KestrelSpec, you can use a National Instruments GPIB interface (NB-GPIB or NB-TNT card, or GPIB-SCSI adaptor box) to connect the spectrograph to the Macintosh.

Use the *NB Handler Init* control panel supplied by National Instruments to name the device "**specA**" on bus **gpib0** at the GPIB address set on the spectrograph. (For information on setting the spectrograph GPIB address, consult the spectrograph manual. In the example window below the spectrograph was set for GPIB address 8. Set the **Timeout** at 3 sec. The presence of the GPIB interface will be automatically detected at start-up.

Configuring the GPIB (IEEE-488) Spectrograph Interface:

(1) Setup GPIB interface:

(2) Setup spectrograph:

NB Handler INIT

National Instruments GPIB Configuration

Interface: System ... 1 2 3 4 5 6

Auto 1 2 3 4 5 6

NI-488 Bus#: 0

Bus/Device: gpib0

Primary: 0 Write END on Last Byte

Secondary: None Write END on EOS

Timeout: 3 sec EOS Byte 0 8 Bit

System Controller Repeat Addressing

REN when SC Unaddressing

DMA

NB Handler INIT

National Instruments GPIB Configuration

Interface: System ... 1 2 3 4 5 6

Auto 1 2 3 4 5 6

NI-488 Bus#: 0

Bus/Device: specA (Rename)

Use Bus: gpib0 Write END on Last Byte

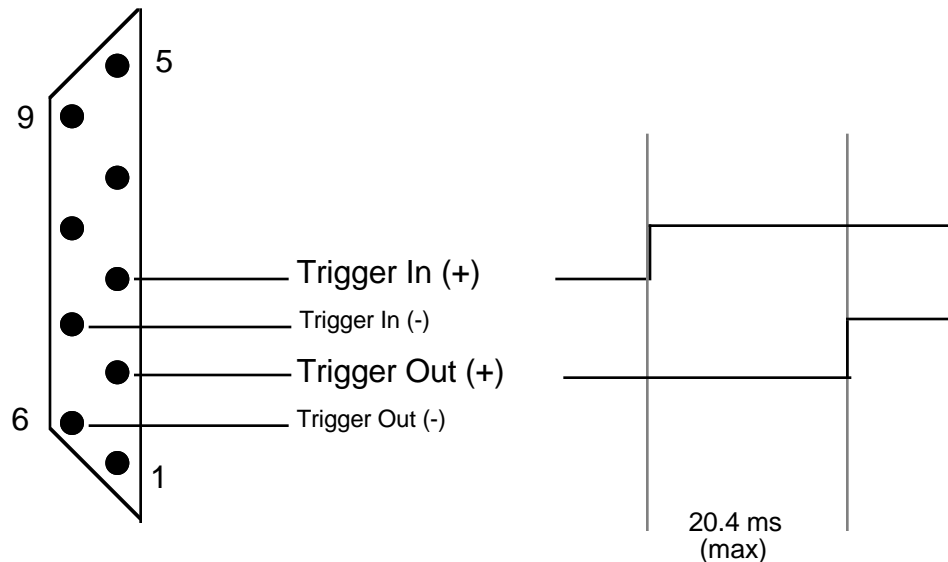
Primary: 8 Write END on EOS

Secondary: None Read END on EOS

Timeout: 3 sec EOS Byte 0 8 Bit

Triggered Data Acquisition with the ST-6I CCD

You can enable triggered data acquisition if the ST-6I ROM version is 3.05 or 3.07. The TTL-compatible trigger signals appear at the AUX port on the ST-6I controller (diagram below).



ST-6I "AUX" Port Connections for Triggered Data Acquisition

Using Trigger In

When the *Setup:Camera Configuration* menu is setup to enable *Trigger In*, pin 3 of the AUX port will wait for a high TTL (+5 volt) level with respect to electrical ground before taking an exposure. (If desired, the logical complement, i.e., 0 volts, can instead be applied to Pin 7 to trigger the exposure.) The trigger level must remain valid for a minimum of (1/baud rate) second; at 9600 baud the minimum trigger pulse width is thus 0.104 ms.

Once the trigger-in level is detected, the CCD exposure begins after a latency period which is in part associated with clearing the CCD and, to a smaller extent, due to the AUX port response time. The latter depends on the baud rate in use. The maximum total latency time (using 9600 baud) between the trigger-in signal and the actual start of exposure is 20.4 ms, as shown in the diagram. The minimum latency time (using 57600 baud) is approximately 19.5 ms.

Using Trigger Out

When the *Setup:Camera Configuration* menu is setup to enable *Trigger Out*, pin 2 of the AUX port will make a transition from zero volts to a high TTL (+5 volt) level with respect to ground at actual start of an exposure, i.e., the pulse appears after the CCD has been cleared and coincident with the start of integration. (The logical complement of this signal appears at Pin 6.)