# SETTING THE BINNING

Proper binning allows you to maximize the signal-to-noise ratio in your data without compromising resolution. In the following sections, we provide advice for how to bin frames in imaging and spectroscopic modes. *These are recommendations only*. The binning of any frame may be set from the Goodman control software by choosing a standard or custom ROI from the **CCD ROI Mode** drop-down menu on the *Camera Control* panel. Further details on this process are discussed in "SETTING THE REGION OF INTEREST"

## IMAGES:

In imaging mode, one typically wants to 'bin to the seeing' so that there are at least two pixels covering the seeing FWHM. For example, if the seeing is 1.0", then the FWHM of the seeing disk covers 6.7 pixels (the pixel scale is 0.15" per pixel). Thus, one could consider binning up to 3 pixels in the spatial direction. Full instructions follow.

1. **Determine the FWHM of a point source** (in pixels)

   Although the *TCS Panel* (sometimes) displays the current reading from the DIMM seeing monitor, you should independently measure the seeing yourself since the DIMM is not always reliable. Take an image of your field using the same binning in the serial and parallel directions, and locate a point source. Make sure the source is neither digitally saturated (= 65,536 ADU) nor over the full-well value (see REFERENCE GUIDE).
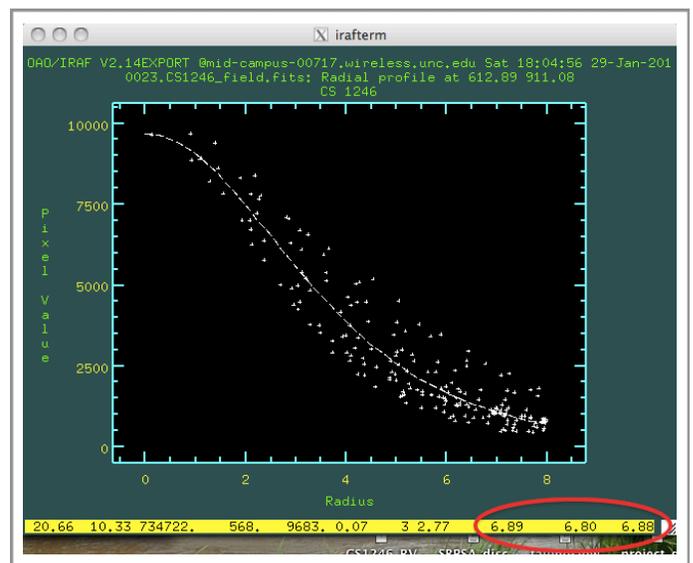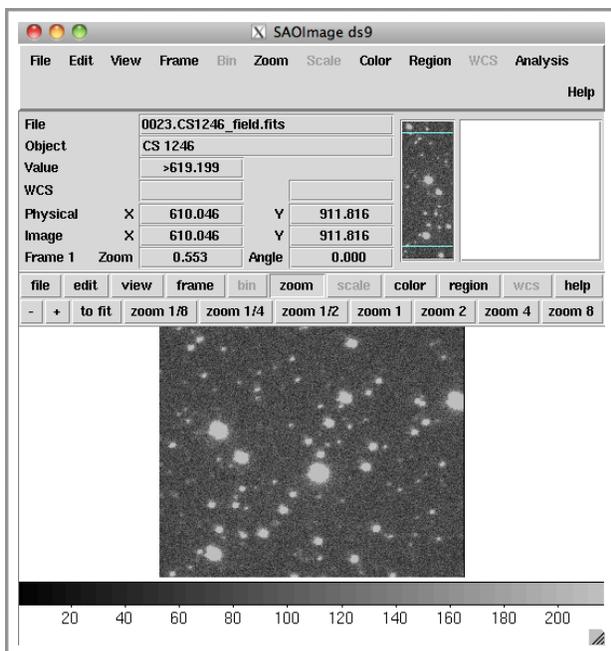
Using a centroiding algorithm, determine the FWHM of the point source.  In the figures above, we employed IRAF to illustrate this process, using the *imexam* routine and the *'r'* keystroke to centroid on a star.  Several measurements of the FWHM are displayed in the lower-right corner of the pop-up window on the right; the average of these is 6.86.

**Note that *imexam* provides the FWHM in terms of *binned pixels*.**  If the image you used was binned, multiply your answer by the binning to get the FWHM in terms of unbinned pixels:

    ***EXAMPLE:***   *FWHM x binning = 6.86 binned pixels * 2 pixels per binned pixels = 13.7 pixels*

## 2. Determine the best binning

The FWHM should be resolved with *at least* two binned pixels.  Thus, if you divide the FWHM by two, the whole number portion gives you an upper limit for the binning:

            ***EXAMPLE:***   *FWHM / 2 =13.7 / 2 = 6.85 pixels*

In our example, we could bin the image by six or less and still resolve the FWHM with at least two binned pixels.

## 3. Compute the seeing (optional)

To convert the measured FWHM to an estimate of the seeing, multiply by the pixel scale:

    ***EXAMPLE:***   *FWHM x 0.15 arcsec / pixel = 13.7 pixel * 0.15 arcsec /pixel = 2.06 arcsec*

## SPECTRA:

In spectroscopic mode, it is common for the binning to be different in the x & y directions. The procedure for determining the binning in the spatial (parallel) direction is the same as that for images and depends on the current value of the seeing. In the dispersion (serial) direction, one should bin such that the FWHM of one resolution element is resolved using at least two binned pixels.
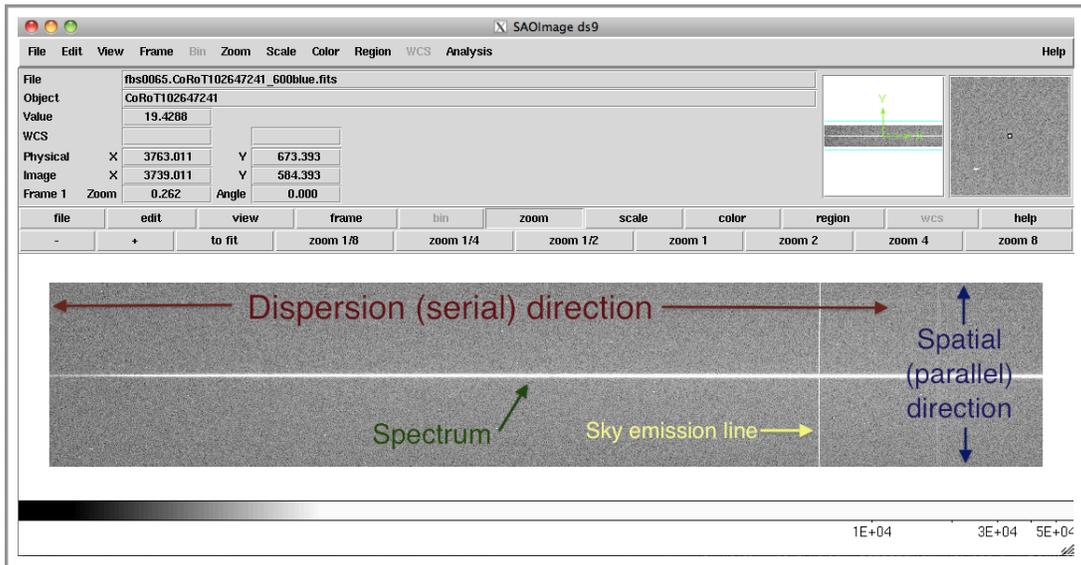


1. **Determine the spatial direction binning**

   Use the procedure given above for determining the best binning in images. The result is the recommended binning in the spatial (parallel) direction.

2. **Determine the best dispersion direction binning**

   Divide the slit FWHM (in arcseconds) by the pixel scale (0.15 arcsec/pixel):

   > *EXAMPLE*:    FWHM / pixel scale = 0.84" / (0.15"/pixel) = 5.6 pixels (unbinned)

   The result means we should measure the FWHM of the 0.84" slit as 5.6 pixels in an image. If we divide this value by two, the whole number portion of the result gives you the upper bound for binning:

   > *EXAMPLE*:    5.6 pixels / 2 = 2.8 pixels

   Thus, we probably do not want to bin by more than 2 in the dispersion (serial) direction. **NOTE:** If your target is smaller than the slit, the FWHM of the slit is no longer a good representation of a single resolution element. Instead, use the FWHM of the seeing disk.