A Tutorial for using the routine SPEC_GAUSS_WIDGET

Version 1, 28-Oct-2008, Peter Young

Introduction

Spectrometers (both solar and astronomical) produce vectors of intensity (or flux) vs. wavelength, and usually there is an associated error vector to go with the intensity. It is thus of value to have a general purpose Gaussian-fitting routine that will take such data-sets and allow the user to fit Gaussians. The present document describes how the routine SPEC_GAUSS_WIDGET works, which is available in the Solarsoft IDL distribution.

Getting Started

SPEC_GAUSS_WIDGET is called as:

IDL> spec_gauss_widget, xx, yy, ee

where XX is the wavelength vector, YY the intensity/flux vector, and EE the error vector. Note that for several instruments, 'wrapper' routines exist that take some standard spectrum output from the instruments and convert them to the spec_gauss_widget format. It is advised that these wrapper routines are used instead of spec_gauss_widget.

After calling SPEC_GAUSS_WIDGET, you will see a graphical user interface (GUI) appear – see Figure 1 for an example.

Details on each of the various features of the GUI are described in the following sections.

Data quality

An optional input to spec_gauss_widget is a data quality vector. This is a measure of how good the data points are, and is best illustrated by an example.

Often a spectrum is generated by averaging over a number of pixels on a detector. Say the average is performed over 10 pixels. We may set the data quality to be the number of pixels for which the average has been performed for each wavelength pixel. For most pixels the data quality factor will be 10. However, there may be a problem with the detector at specific locations, e.g., hot pixels, cosmic rays, dust particles, etc. Therefore in these regions the quality will be lower than 10.

Note that if the averaging has been performed over less than 10 pixels, then this will be reflected in a larger error bar for those wavelength pixels, thus the Gaussian fitting routine should accurately fit these points. However, if the data quality is seen to be particularly low for one or more pixels, then this may lead to clearly anomalous intensity/flux values at those pixels and so the user may want to remove those pixels from the fit.

Therefore one capability of SPEC_GAUSS_WIDGET is to overplot the data quality vector on the spectrum to enable the user to easily see if there are low quality data points in the spectrum.

Graphics Windows

Two graphics windows are seen in the GUI. The large one (the spectrum plot window) is the main window, which will display the spectrum and line fits. The smaller window will show residuals from the fit after the fit has been performed.

Zoom/Unzoom

After clicking on the ZOOM button, go to the graphics window containing the spectrum. Click-and-hold the mouse button, and move the mouse to draw out a 'rubberband' box. When you let go of the mouse button you will zoom into the chosen area.
To zoom back out again, simply press the 'UNZOOM' button.

Note: each zoom requires you to first click on the 'ZOOM' button and then go to the graphics window.

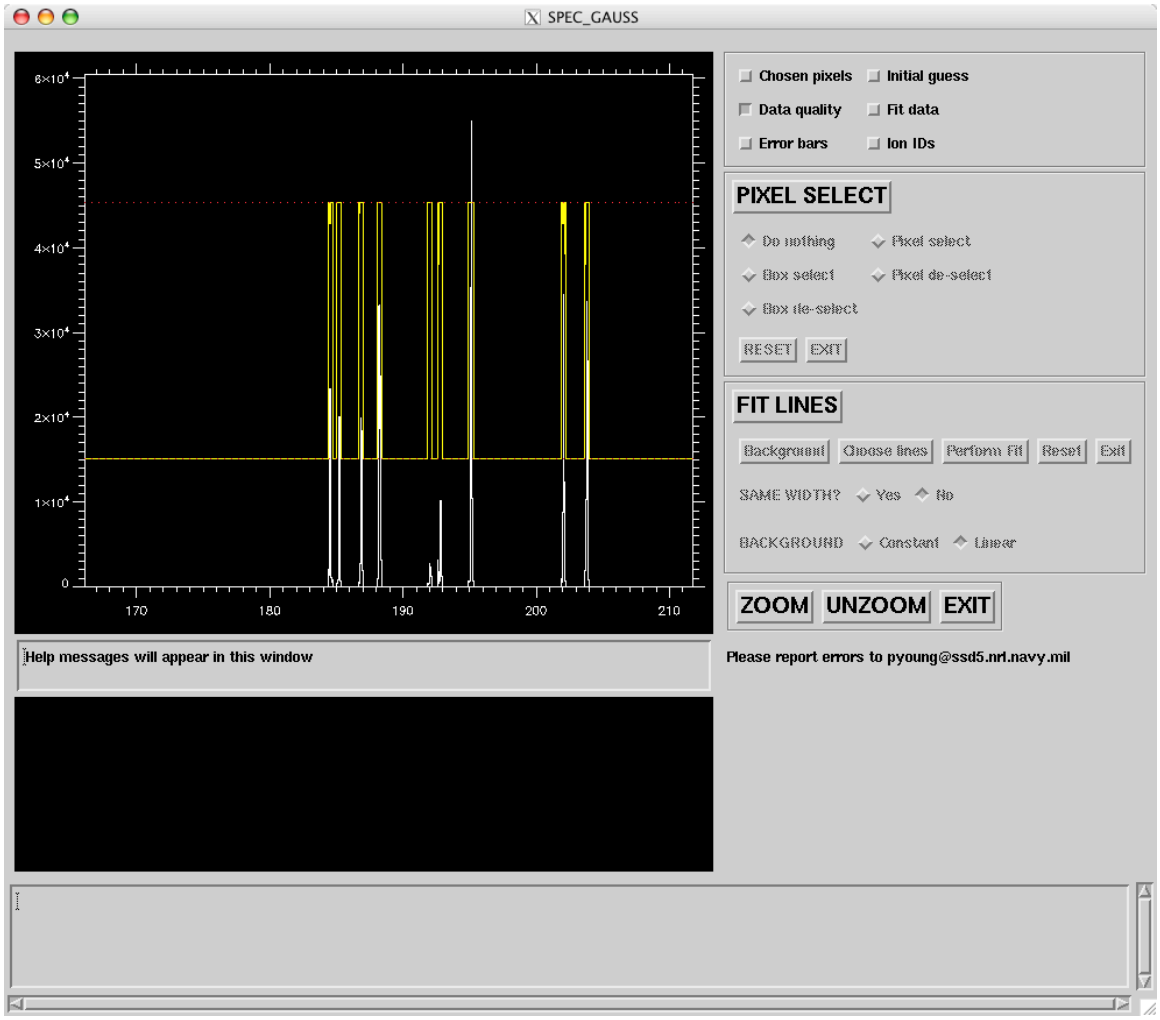

Figure 1. The SPEC_GAUSS_WIDGET GUI.

Plot buttons

These are found at the top right of the GUI. Clicking them adds/removes features from the spectrum plot. They are:

1. *Chosen pixels*. See the 'Pixel Select' section later in this document.
2. *Data quality*. This overplots the data quality vector on the spectrum. Two dotted lines will be displayed at ¼ and ¾ on the Y-axis. These denote the zero and maximum data quality values. The yellow solid denotes the data quality values corresponding to each wavelength pixel in the spectrum. If the yellow line reaches up to the upper dotted line, then it means that pixel has the highest data quality; whereas if the yellow line reaches down to the lower dotted line, then that pixel has a zero data quality value.
3. *Error bars*. Overplot the errors bars on the intensity/flux values.
4. *Initial guess*. This is only operational after a line fit has been performed – see the 'Fit Lines' section. If set, then the initial fit parameters (background and peak intensity values) will be overplotted on the spectrum.
5. *Fit data*. Again, this will only be operational if a line fit has been performed. If set, then the fit function will be overplotted on the spectrum.
6. *Ion IDs*. Clicking this button will overplot suggested line identifications on the spectrum. This will only be operational if a line identification file has been input to SPEC_GAUSS_WIDGET. Typically the wrapper routine for a particular instrument will specify a line identification file that is suitable for that instrument.

Pixel Select

Often when fitting Gaussians to a spectral region, one may want to exclude certain wavelength pixels from the fit. Reasons include:

1. A pixel has a low data quality value
2. Artifacts in the data (e.g., hot pixels)
3. A region may be of no interest, but the regions either side may be valuable (e.g., for correctly estimating a background level).

Clicking on the 'PIXEL SELECT' button activates the pixel selection widget, allowing particular pixels or regions to be selected or de-selected. Note that, when clicking the 'PIXEL SELECT' button, all other widgets on the GUI become de-sensitised. You need to click on the 'Exit' button within the 'PIXEL SELECT' widget to go back to the main GUI.

After clicking on 'PIXEL SELECT' you will see a row of stars appear across the middle of the spectrum, and more stars will be overplotted on the spectrum. These stars denote the pixels that will be used for the fit if the fit was to be performed now. Note that no pixels outside of the plot window will be used.

Pixels can be selected/de-selected either pixel-by-pixel (using the Pixel select/de-select buttons), or a region at a time (using the Box select/de-select buttons).

Box select/de-select

After clicking on one of these buttons, move your mouse to the spectrum plot window, and draw a rubberband box on the spectrum (click-and-hold the mouse button and drag the mouse to draw the box). The Y-size of the box does not matter, but all wavelength pixels that lie within the X-limits of the box will be selected. If 'Box de-select' had been chosen, then the stars will disappear in the selected wavelength range, indicating that the pixels have been de-selected.

You can select any number of regions using the rubberband box. When you are finished, *click in the margins of the plot window*. I.e., outside of the plot axes. (This method of exiting is used several times in SPEC_GAUSS_WIDGET.) This takes you back to the Pixel Select widget.

Note that pixels with a zero data quality value can never be selected.

Pixel select/de-select

After clicking on one of these buttons, go to the spectrum plot window and click with the mouse button on the pixels you want to switch on or off.

To exit, click in the margins of the plot window.

Reset

This resets the selected pixels back to the original state, i.e., all pixels selected in the plot window except those with zero data quality.

Fit Lines

Like the 'PIXEL SELECT' button, the 'FIT LINES' button de-sensitizes the rest of the SPEC_GAUSS_WIDGET and takes you into a separate widget. To exit out of this widget, click on the 'Exit' button.

Background

Clicking on this button allows you to choose a default value for the spectrum background. Go to the spectrum plot window and click once at the level you think the background is. A thick horizontal line will appear overplotted on the spectrum.

Choose lines

Clicking on this button allows you choose initial parameters for the emission lines. Go to the spectrum plot window and, for each line you want to fit, click-and-hold the mouse button and drag the mouse down and outwards. You will see a blue triangle appear. The peak of the triangle should correspond approximately to the peak of the line, while the width of the triangle should correspond to the full-width at half-maximum (FWHM) of the emission line. Let go of the mouse button when you're happy with your estimate.

You can repeat this procedure to select as many lines as you want. Each line you select will correspond to a Gaussian in the fit function to be used by the routine.

When you are finished you can exit this part of the routine by clicking in the margins of the plot window.

Perform fit

Clicking this button will perform the fit. The total fit function will be over-plotted as a thick yellow line, while the fitted background will be plotted as a blue line.

Figure 2 shows an example single Gaussian fit. The spectrum is shown as a white stepped line, and the fit to the emission line is shown as a thick yellow line. The background level is shown by a blue line. The thinner, yellow line shows the data quality for this spectrum (see earlier section).

If you're not happy with the fit, you can use the 'SAME WIDTH?' or 'BACKGROUND' buttons to force each emission line to have the same width, or to make the background level a constant (rather than a straight line). After selecting your option, simply click on 'Perform fit' to re-do the fit with the same initial conditions.

If you want to change the initial parameters, then you need to click on the 'Reset' button and restart the process.

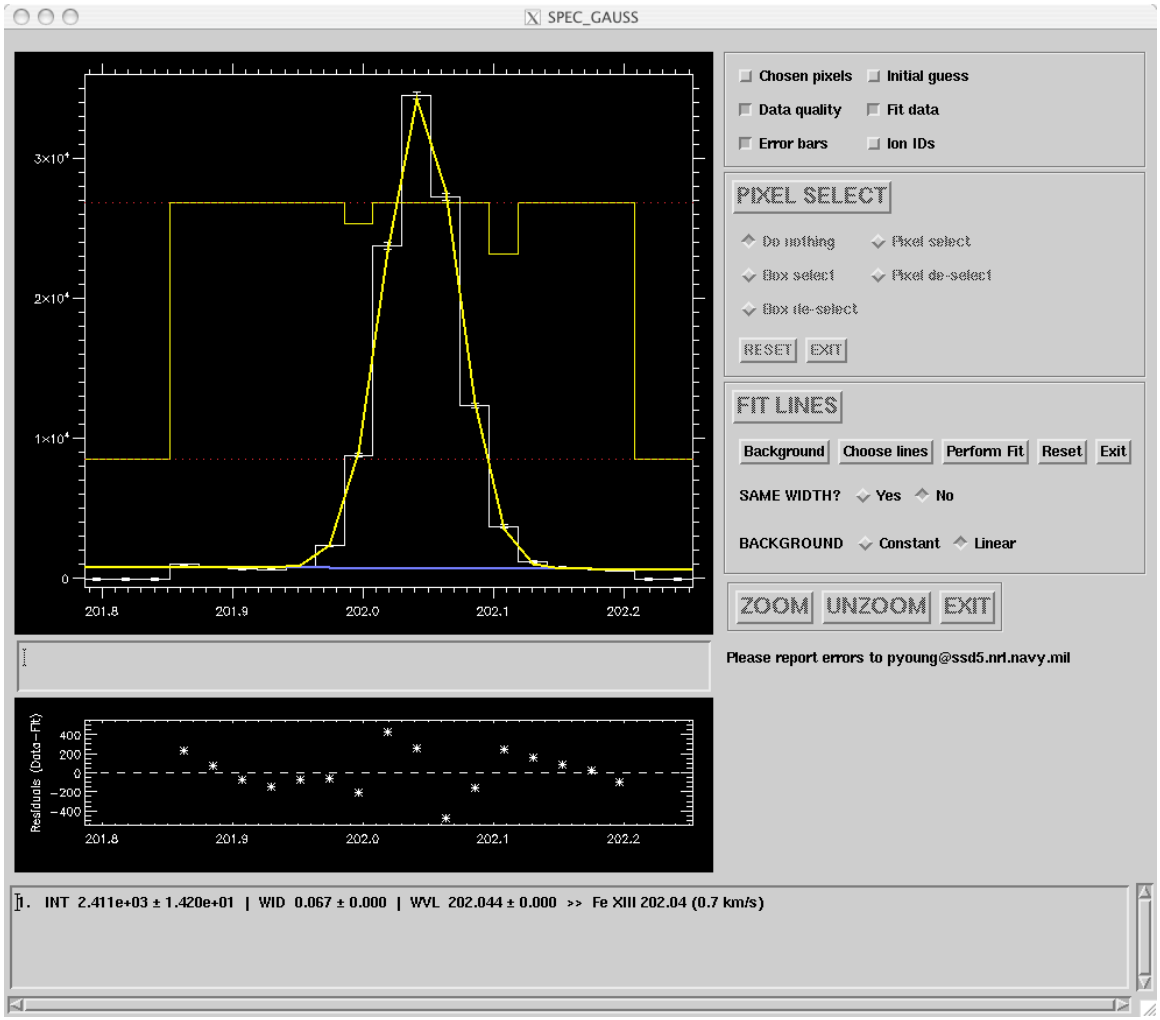

Figure 2. A fit to the Fe XIII 202.04 emission line (from a Hinode/EIS spectrum). See main text for more details.

The fit parameters for each of the Gaussians will be displayed in the text box at the bottom of the GUI. If a line identification file has been supplied, then suggested line identifications from CHIANTI that lie close to the fitted line will be printed, together with the velocity difference between the fitted line and the CHIANTI line. (See Figure 2 for an example.)

Exit

If you're happy with the fit, then clicking on Exit will send the fit parameters (with error bars) to a file called 'spec_gauss_fits.txt' in your current working directory. Each new fit gets appended to this file.

If you do not want to print the fit parameters to the text file, simply click the ‘Reset’ button before clicking the ‘Exit’ button.