PriMaRy JOVE Analysis Documentation

Stuart Mumford
stm7@aber.ac.uk
Planetary and Space Physics Group
Aberystwyth University

Keiron Pizzey
kpp7@aber.ac.uk
Condensed Matter Group
Aberystwyth University

May 2010

1 Installation

The PriMaRy JOVE Analysis program and its associated files can be installed using the provided installer program onto any machine with Windows XP or greater. The installer provides custom options for the end-user including file location and such.

N.B. Under no circumstances should the user edit/delete any of the python source files included with the installation package; doing so will render some functions of the program unusable or, even worse, give you false results.

2 Loading Data

Data is input into the PriMaRy JOVE Analysis Program through selecting the "Open" button in the top left-hand corner of the window. A dialog box will open where you can navigate to your data files. Data can be input through the file types:

- Skypipe Data (.spd)
- Comma-Separated Variable (.csv)
- Flexible Image Transport System (.fits)

N.B. When using Skypipe Data the user can only have a file with the time channel AND ONE DATA CHANNEL. This problem is due to the SPD2FITS converter and is beyond the Author's control.

When using a CSV file it is important that the time/data is saved in the correct format. It is suggested that the first time the end-user is running the program they use Skypipe Data, after the user has ran the program the program will have automatically saved a .spd.fits file (a .spd file converted to .fits) which can then be used in any further runs to speed up computation. If the end-user chooses to use .csv they should be aware that the data must be saved into rows and not columns.

Upon successful opening of a data file the program will output some parameters to the user:

- File Open = Directory/Name of currently opened file;
- File Starts = Starting Date/Time of data file;
- File Ends = Ending Date/Time of data file;
- Length of File = Time length of file in minutes;

- Number of Samples = Total number of data points in file.

Upon loading the data will also be automatically plotted to the built-in graphing window.

3 Binning the data

Binning the data involves averaging sections of the array and re-assigning this value to a new array; binning the array reduces the number of data points but also helps to remove noise from the signal. The time-length of the bins is the time that a bin spans, for instance if the bin length were 10 minutes then all data points in a 10 minute window would be averaged. The authors recommend a binning time of no greater than 10s as radio events can occur on quite small time-scales and choosing a time-length too large reduces resolution significantly.

After binning the data it is necessary to click the *Save Current Data* button. Even though the binned data may be plotted to the graphics window it is not the current data array and as such any further data analysis will be applied to the original raw data if you do not save the binned data.

4 Band Pass Filtering

The band pass filter is a simple FFT filter algorithm. FFT filtering involves fourier transforming a signal from the time domain into the frequency domain and then only allowing certain frequencies to pass through the filter. The signal is then inverse fourier transformed back into the time domain resulting in a signal with unwanted frequencies removed.

The band pass filter is controlled by two user-defined parameters, "filter limit" and "filter type".

- Filter Type = The type of filter used.
  - High = All frequencies **below** a given limit will be set to zero;
  - Low = All frequencies **above** a given limit will be set to zero.
- Filter Limit = The limit at which frequencies will be removed.

For example data used to test the PriMaRy JOVE Analysis Program a filter limit of approximately 120 yielded good results however it is left to the user to experiment with values to see what fits their data best. After using the band pass filter **it is necessary to click the *Save Current Data* button to save the array.**

A word to the wise: Be careful with band pass filter, you can very easily destroy a signal or create false ones through frequency artifacts!

5 Window Function Smoothing

Window function smoothing (also know as Apodization smoothing) involves convoluting a window function (type and length chosen by user) with the signal. By selecting different window types and window lengths it is possible for the user to remove different magnitudes and types of noise.

- Window length = Must be an integer greater than or equal to 3. The higher the integer the more noise is reduced.
- Window type = Choice of five different types is given with different windows having different properties.
  - Bartlett;

- Blackman;
- Flat;
- Hanning;
- Hamming.

Window smoothing is not as "powerful" as the band pass filter in removing noise, however it is more likely to not destroy a signal. The authors would recommend using the band pass filter (and being careful) rather than using window smoothing when all things are considered.

6 Peak Finding

Included with the PriMaRy JOVE Analysis program is a peak finding subroutine. This subroutine will automatically search through the smoothed data for peaks meeting certain criteria and then use non-linear regression to fit a gaussian function (Equation (1)) to that peak. The non-linear function used is the Levenberg-Marquardt Algorithm which iterates through parameter space in order to minimise the residual between fitted data and measured data. A peak is defined as a point of inflexion (gradient changing from positive to negative) above a certain height, the height chosen by the user. The user chooses the number of standard deviations, less standard deviations will result in more peaks being fitted.

$$y = ae^{-\frac{(x-b)^2}{2c^2}} + d \tag{1}$$

The user is also given the option of saving to a CSV the parameters of the gaussian function, these parameters are:

- a = Height of peak;
- b = Central position;
- c = Width parameter;
- d = Vertical offset.

From c, the width parameter, the FWHM can be gained: $FWHM = 2\sqrt{2ln(2)}c$.

7 Automated Data Analysis

The automated data analysis option is a simple option which will bin, band-pass filter and peakfind a raw data set for options given by the user, it saves the user from running the analysis one function at a time.

8 Plotting to New Window/Custom Plotting

The user is given the option of plotting to a new window rather than keeping the graph in the in-window graphing widget. This option is given so the full power of matplotlib's plotting library can be used in plotting the graph rather than the minimal widget.

In plotting in a new, external window the user will be able to zoom in on areas, pan around the graph and save the current view to an image file. The controls for the graphing options are located in the top left hand corner of the graphing window, however there is a bug which the authors have been unable to fix. Icons for the controls do not appear (apart from one), the icons available (in order of left to right) are:

- Home - Return you to original view of graph;
- Back - Skip to previous view;

- Forward - Skip to next view;
- Pan - Pan around the graphing screen;
- Zoom - Zoom in on an area by selecting an area;
- Configuration - Configure the plot areas;
- Save - Save image to file.

The Alt-Text can also be accessed if the mouse button is hovered over the button.

Custom-Plotting mode is similar to "Plot in new window" however further options of graph title and graph axis labels are given.

9 Saving Data

The user's final option is to save data to files for use in other data analysis programs or use in graphinc functions. The user is given the option of either saving the full array or saving a portion of the array. To save a portion of the array the user must enter the start time and end time. The user can either save as a csv or a text file depending on their preference.